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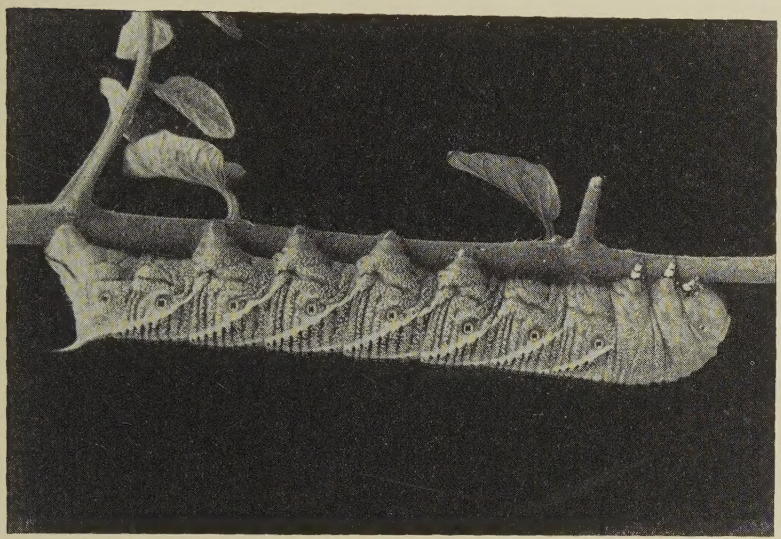
The Control of Diseases and Insects Affecting Vegetable Crops

C. R. Crosby and Charles Chupp



COURTESY OF P. J. CHAPMAN

TOMATO WORM

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Joint publication from the Departments of Entomology and Plant Pathology.

THE CONTROL OF DISEASES AND INSECTS AFFECTING VEGETABLE CROPS

C. R. Crosby and Charles Chupp

In this bulletin an attempt is made to bring together in available form all the more pertinent facts concerning the practical control of the insects and the diseases affecting the more important vegetable crops in New York State. Much of this material has been published in bulletins or elsewhere but is available only to those who have access to a large agricultural library. Considerable additional information has been obtained from unpublished data of the research workers of the state experiment stations. Doctor Hugh Glasgow of the New York State Agricultural Experiment Station at Geneva, New York, has been especially helpful in furnishing information and in making suggestions as to the best methods of control. Many valuable suggestions have been received also from the county agricultural agents in those counties where vegetable growing is a major enterprise. It is hoped that this summary will be of use to the growers of the State in their efforts to produce paying crops of vegetables.

The present revision of this bulletin was made late enough in the fall of 1931 to take advantage of the experimental findings of the year. It therefore contains the latest information available and may serve as a guide for controlling insects and diseases during 1932.

CABBAGE, CAULIFLOWER, AND RELATED CROPS

The most serious insects and diseases with which the cabbage grower has to contend in growing the crop are root-maggots, black-rot, black-leg, aphids, and worms. Seed treatments are required for the control of black-rot and black-leg. To effectively prevent loss in the seedbed, mercury treatments are required for maggot, wire-stem, and club-root control. Summer treatments are confined largely to dusting or spraying for aphids and worms.

CABBAGE ROOT-MAGGOT

(*Hylemyia brassicae* Bouché)

The cabbage root-maggot is a serious pest in seedbeds of late cabbage and cauliflower. It attacks also early crops of these vegetables in the field as well as brussels sprouts, broccoli, and turnips. Radishes are especially subject to infestation. Fortunately late crops of cabbage and cauliflower usually escape serious injury in the field.

The adult of the cabbage root-maggot is a fly resembling the house fly in general appearance. It is about the same size but appears narrower, owing

to the way the wings are held when at rest. The flies appear about the time sweet cherries come into bloom, and reach their maximum abundance when plums of the Gage type blossom. They may be observed on sunny days resting in sheltered spots on the seedling plants. When disturbed, they take wing quickly and, after a short rapid flight, usually come to rest on another plant a few feet away. The female fly is provided with a long extensile ovipositor with which she places her eggs in cracks in the soil close around the base of the plants. The eggs are white, elongate, and can be easily seen with the unaided eye. They are most readily found by removing the soil around the stem of the plant with a knife point. Most of the eggs will be found within ¼ inch of the surface.

The eggs hatch in from three to eight days, and the minute, whitish maggots work their way down along the stem and the root, feeding at first only on the surface. They rasp the surface tissue with their hook-like mouth parts; and as the maggots increase in size, they channel out deep grooves or burrow into the larger roots or the base of the stem. Infested seedlings take on a lighter color than normal and acquire a bluish cast. They wilt more quickly in the heat of the day. Later they turn a yellowish color, wither, and die.

The maggot becomes full-grown in about three weeks, and then transforms into a brownish puparium, usually in the soil close to the injured plant. A second brood of flies appears in from twelve to eighteen days, and one or two additional broods may develop later in the season. Most of the injury to cabbage and cauliflower, however, is caused by the first, or spring, brood of maggots. Radishes and turnips, however, may be seriously injured later in the season.

Control in seedbeds

Two methods of controlling the cabbage root-maggot in seedbeds have been devised and are now widely practiced by commercial growers. Screening the beds with cheesecloth was the first practical method discovered. It was soon adopted by the growers of late cabbage in western New York and is still widely practiced in that region. In the other method of control a solution of corrosive sublimate is applied to the soil around the plant to kill the eggs and the young maggots. This method was first developed to control the maggot on early cabbage in the field but is now extensively used in the seedbed.

Screening

The purpose of screening the seedbeds is to exclude the flies, and thus prevent the deposition of eggs. A moderately coarse grade of cheesecloth has been found to be the best material with which to cover the beds.

Cheesecloth having from 20 to 30 threads to the inch is, on the whole, the most satisfactory. If more tightly woven, it will exclude too much light and will make the plants weak and spindling. If too loosely woven, it is likely to pull apart and permit the entrance of flea beetles.

The screen should be installed soon after the seed is planted and before the flies have had an opportunity to deposit their eggs around the young plants. The cloth may be spread directly on the ground without any support or it may be fastened to a frame of boards, set on edge to form a tight wall around the bed. Either method affords effective protection, but the latter is preferable although more expensive.

For the supporting walls surrounding the bed, boards 6 to 12 inches wide should be joined tightly together at the ends. The cloth is stretched across the enclosure and attached to the boards with strips of lath. If the bed is large, the cloth can be kept from sagging by stretching galvanized wires across the bed. If the cloth is placed directly on the ground without the frame, it should not be stretched too tightly; enough slack should be left to provide ample space for the growth of the plants. The edges can be held in place with splinters of wood or with stones.

The screen can be removed during weeding and cultivation, but the plants should not be exposed longer than necessary, especially during bright warm days when the flies are active. If the cloth becomes torn, it should be repaired without delay. In order to harden the plants, the screen should be removed a week or ten days before they are transplanted. If it is taken off too early, a serious maggot infestation may result, especially if the plants mature during the height of the egg-laying period.

Owing to the protection afforded by the screen, the percentage of germination is increased and less seed is needed to give a good stand than when planted in open beds. It is therefore advisable to sow the seed thinner in screened beds, and thus prevent overcrowding the plants and the necessity of thinning them. Under the climatic conditions prevailing in western New York, cabbage plants make better growth under screens than in the open, and care should be exercised in the use of fertilizers.

Corrosive-sublimate treatment

For protecting seedling cabbage plants from root-maggot attack, corrosive sublimate is used at the rate of 1 ounce of the finely divided powder in 10 gallons of water. The powder is dissolved in a small quantity of hot water and then diluted to the required amount. The solution should not be stored in a metal container because of its corrosive action.

Corrosive sublimate is effective only against the eggs and the newly hatched maggots. In early plantings the first application should be made when European plums of the Green Gage type are in bloom. In later plantings, where the flies have already appeared and are laying eggs, the

first application should be delayed until from three to five days after the plants have come up, to avoid injuring them. Two or three applications at weekly intervals may be found advisable, depending on the abundance of the flies.

The corrosive-sublimate solution may be applied to the plants by means of a watering pot from which the perforated sprinkler has been removed or by some better device, such as a small tank mounted on a wheel-barrow. The solution is poured along the row so as to moisten the soil around the base of the plants. One gallon of the solution will treat 40 feet of row for the first application; in later applications more will be required. If a heavy rain follows immediately after an application of corrosive sublimate, it may be advisable to make the next treatment a little sooner than would be required by the regular schedule. It is well to wait two or three days, however, before repeating the application.

Cauliflower seedlings are more subject to injury from corrosive sublimate than are cabbage seedlings, and it is therefore advisable to use it at a greater dilution—1 ounce in 15 gallons of water for the first application, and 1 ounce to 10 or 12 gallons for the others.

Calomel treatment

For the treatment of the tender seedlings of cauliflower and brussels sprouts, an aqueous suspension of calomel may well be substituted for the corrosive-sublimate solution. This applies also to the treatment of cabbage seedlings that have been attacked by flea beetles, where the use of corrosive sublimate is likely to augment the injury. The use of calomel under such circumstances will avoid injury to the plants and will give excellent control of the maggot if properly applied.

Calomel may be used according to the general directions given for corrosive sublimate except that the calomel, being insoluble, must be constantly agitated while the suspension is being applied. Also, in some cases it may be advisable to increase the dosage of calomel to 2 or 4 ounces to 10 gallons of water. A single application of calomel at this strength will often give the same degree of control as that usually obtained from the three generally recommended applications of corrosive sublimate. Were it not for the difficulty of keeping the calomel in suspension while making the treatments, its use would be much more general than it is at present.

Both corrosive sublimate and calomel are mercury compounds. Corrosive sublimate is also known as *mercuric chloride,* and calomel as *mercurous chloride.* Because of the similarity of the chemical terms, confusion is likely to arise, and it is better to use the common names for these substances. The finely ground commercial corrosive sublimate commonly

found on the market is satisfactory for maggot treatment. Calomel does not dissolve in water but is applied in the form of a suspension. It is therefore essential to use a very finely divided product, like flour.

Recent experiments indicate that by treating cabbage and cauliflower seed with dry calomel powder, maggot injury to the seedlings can be greatly reduced. The seed is moistened and worked up with the calomel. About 1½ pounds of the powder will adhere to 1 pound of the seed.

Control on early cabbage in the field

When cabbage or cauliflower seedlings are transplanted into the field during the egg-laying period of the flies, the plants are likely to become heavily infested by maggots and seriously injured or killed. The most practical way to prevent this loss is to use corrosive sublimate as described for the treatment of seedbeds. Two or three applications at weekly intervals may be found necessary, depending on the abundance of the flies and the time at which the seedlings are set out in the field. The first applications should be made within three or four days after the seedlings are transplanted. About 2 or 3 ounces of the corrosive sublimate solution is poured around each plant at each treatment. The solution may be applied with a pail and dipper, with a watering pot from which the sprinkler cap has been removed, or with some mechanical applicator.

An older method of control is still practiced to a considerable extent on Long Island. A mixture of tar and sand is applied around the base of each plant to prevent the flies from laying their eggs. The results obtained by using tar and sand are not so satisfactory as those obtained from treating the plants with corrosive sublimate, and Long Island growers are gradually adopting the latter method of control.

Control on radishes

Radishes are especially subject to infestation by root-maggots. Here the damage is measured, not by the decrease in thrift of the plants or by the size of the crop as a whole, but by the proportion of radishes infested by maggots.

It is often possible to grow radishes comparatively free from maggots by adopting certain preventive measures, such as early planting, so that the crop matures before June 1, locating the radish planting far removed from any fields heavily infested by maggots the previous year, and increasing the size of the planting to a point where the proportion of infestation is relatively small. In small plantings or where the growing period coincides closely with the egg-laying activity of the flies, control measures are often necessary to protect the radish crop from infestation. Radishes may be grown wholly free from maggot injury by protecting the bed with

a cheesecloth screen supported by a wall of boards, set on edge as described for the protection of cabbage seedbeds (page 6). Plants under such a screen usually grow more rapidly and are more succulent than are those grown in the open, and, if the screen is properly constructed, maggot injury should be entirely prevented.

Equally good control of maggot injury can be obtained by the use of corrosive sublimate. This method is somewhat less expensive than screening and the solution is easy to apply. Corrosive-sublimate solution, 1 ounce in 10 gallons of water, is applied to the plants at the rate of about 1 gallon to 30 feet of row. The solution should be applied in such a way that the soil immediately about the plants is moistened by the liquid. The first treatment should be made as soon as all the plants are well through the ground, and one or two later applications should be made at intervals of about a week. In some cases one treatment will be found to give ample

COURTESY OF J. G. HORSFALL

FIGURE 1. DIFFERENCE IN STAND FROM SEEDLINGS FROM A HEALTHY SEEDBED (LEFT) AND FROM A SEEDBED INFESTED WITH BLACK-LEG OF CABBAGE (RIGHT)

protection from the maggot, but usually it is safer to make two applications; if the crop is making a slow growth, three applications are sometimes needed to insure complete freedom from injury.

Under certain conditions a suspension of calomel, 1 ounce in 10 gallons of water, can be substituted for the corrosive-sublimate solution in treating radishes. It is applied in the same way as is corrosive sublimate, but almost constant agitation of the solution is necessary to prevent the particles of calomel from settling to the bottom of the container. Calomel is safer to use on young radish plants than is corrosive sublimate, especially where severe flea-beetle injury is present. Under such conditions corrosive sublimate is likely to injure the plants more or less. Calomel has the further advantage of remaining effective in the soil for a longer period. If the quantity of calomel be increased to 3 or 4 ounces to 10 gallons of water, a single application may be expected to give the same protection as two or even three treatments with corrosive sublimate.

BLACK-ROT

(Caused by *Bacterium compestre*)

Black-rot attacks many cruciferous plants, including cabbage, cauliflower, brussels sprouts, turnips, and most other members of the mustard family. The bacteria live on the seed or in the cabbage refuse in the soil, and after gaining entrance into the seedling cause a yellowing or browning of the foliage, which shrivels and dies. Young plants may be

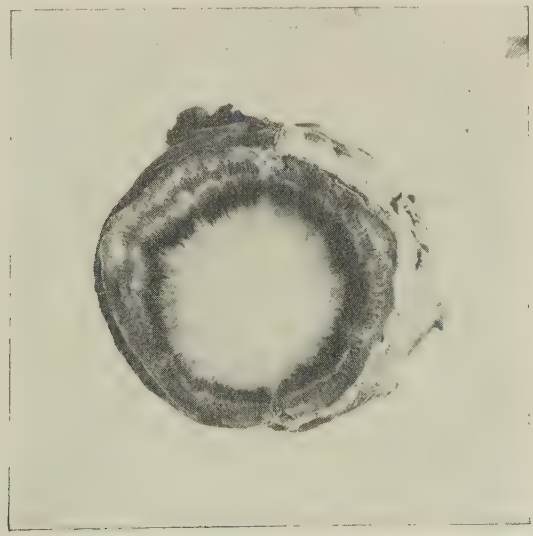

FIGURE 2. A DARK RING IN A CABBAGE STEM CAUSED BY BLACK-ROT

killed outright, but in older plants the organism merely blackens and kills the veins through which it advances. It also produces a typical black ring in the stem. Often the heads are dwarfed or one-sided, and later may decay, falling off in a slimy heap. For this reason it sometimes is named *stump-rot.*

Control

Too much emphasis cannot be laid upon having disease-free soil for the seedbed and in avoiding contaminated manure and diseased cabbage refuse both in the seedbed and the field. A three- or four-year crop rotation should be practiced, the grower bearing in mind that rape, kale, turnips, wild mustard, and many cruciferous weeds are susceptible hosts. All other recommendations are worthless, however, if seed from disease-free crops is not obtained or seed treatment is not practiced. The treatment is very simple and inexpensive. One tablet of corrosive sublimate is dissolved in 1 pint of water, or 1 ounce of the poison in 7½ gallons of water. This chemical corrodes metal and in doing so is weakened, so that it is advisable to employ only glass, wooden, or earthen containers. The seed is tied loosely in cheesecloth and is placed in the solution for twenty to thirty minutes. The bundles are stirred until all the air is removed from the cloth, thus insuring the wetting of the seed. The seed is then removed and rinsed thoroughly in clean water and dried. The seed should not be dried over a hot stove or in the direct sunlight. After treatment the seed may be planted at once or stored until needed.

BLACK-LEG

(Caused by *Phoma lingam*)

Black-leg may result in almost the complete loss of the cabbage crop. Aside from cabbage it affects also cauliflower and other crucifers. The first symptom is the sunken area on the stem near the ground line. The areas extend in size and depth until the stem is girdled. Small black dots, the fruiting bodies, develop within the lesion and bear innumerable spores. The spores are splashed by rain, or possibly carried by insects, to neighboring stems and leaves, where new infections arise. The fruiting bodies develop upon the affected leaves the same as upon the stem, so that their presence in the dead areas is an excellent diagnostic symptom. The organism may live for at least three seasons in the soil, and is carried on and in the seed.

When infected seed is planted, the cotyledons, pushed above the soil by the stem, serve as a fruiting place for the parasite. Infection also occurs at the base of the new stem from the mycelium harbored under the seed-coat. Dissemination and inoculation take place rapidly. A few infected seeds may be the source of an epidemic later. A common method by

which this is brought about is the practice of pulling up a large number of young plants and placing them together in water. If spores are present, every seedling may become contaminated under such conditions.

The Phoma is very susceptible to environmental conditions. In the Puget Sound district, where the rainfall from May to July is extremely light, there is very little, if any, of the disease present. It is said also to be absent from Denmark. In New York State it may be rare for several seasons, then become epidemic in nature. The severity of the disease is in direct proportion to the amount of rainfall in the early summer.

Control

Since the fungus remains alive in the soil at least three years, it is necessary to practice at least a four-year rotation. The diseased stalks and leaves should not be fed to cattle, and great care should be exercised in preventing the spread of diseased cabbage refuse to other parts of the farm. If one field is diseased and another is healthy, it is a good plan to use different sets of tools in cultivating the soil of each, for the fungus may be carried readily from one place to another on the tools. No seedlings should be transplanted from a seedbed which shows even the slightest infestation. If possible, only seed coming from disease-free sections should be used. In the past such a practice has not been feasible because the seed growers were careless in their selections. It is now possible to obtain clean cabbage seed from the Puget Sound section or from Denmark, where the disease does not normally occur. A number of the eastern seed growers also are exerting every effort to grow cabbage seed free from Phoma, so that as time goes by it will become easier to procure clean strains of cabbage. In the meantime the seed should be treated.

A large tub or clothes boiler is partly filled with water and heated to 122° F. The small cheesecloth bags of seeds are placed in the water for twenty-five minutes, the water being stirred constantly and the temperature determined with a thermometer. As soon as the temperature begins to lower, a small amount of boiling water is added slowly so that the temperature is kept constant. At the end of the treatment the bags are removed, dipped in cold water to cool, and the seed spread out to dry. This treatment will reduce the germination considerably, especially if the seed is more than one year old, but a large loss is justified in eliminating an organism that may destroy the entire crop. Inasmuch as some lots of cabbage seed are more susceptible to heat injury than are others, it is better to treat a sample of the seed and test its germination before treating the entire amount. The growers who live in counties where the farm bureau furnishes the hot-water-treatment service should by all means take advantage of this opportunity of freeing their cabbage seed of black-leg.

BACTERIAL LEAF-SPOT

(Caused by *Bacterium maculicola*)

Bacterial leaf-spot occurs in most cauliflower fields and sometimes also in cabbage fields. The leaves may be covered with numerous small brown or purple spots, ranging in size from mere points to ⅛ inch in diameter. When badly diseased, the leaves turn yellow and drop off. The spotting may occur also on the white part of the cauliflower. The greatest loss, however, is in the cauliflower seedbed, the plants of which may appear as darkened bunches when the air, under glass, is saturated with water, which permits rapid spreading of the disease from centers of infection.

The disease is caused by a bacterium that is disseminated on the seed and in diseased plant parts. In the presence of moisture the parasite enters the breathing pores of the leaf, where in from three to six days visible infection occurs. It grows best at medium temperatures, but does not develop when the air is much above 84° F.

Control

When the disease has been severe, the control measures consist in changing the location of the hot bed, in at least a two-year crop rotation in the field, and in treating the seed as suggested for the control of black-rot (page 12).

STRIPED CABBAGE FLEA BEETLE

(*Phyllotreta vittata* Fabricius)

The striped cabbage flea beetle is about 1/12 inch in length, black in color, and marked with a wavy yellowish stripe on each wing cover. The larvae of this beetle feed on the roots of cabbage, radish, and wild mustard. The beetles hibernate in sheltered places and appear in the spring in cabbage seedbeds, where they may cause great damage to the young seedlings soon after they appear above ground. When abundant, the beetles may even work their way down below the surface of the ground and destroy the young plants before they come up.

Control

Cheesecloth screens, if properly constructed, have been found to afford complete protection from flea beetles if care is taken not to admit the insects when the cloth is removed for cultivating or weeding the seedbed. To be effective, the cloth used should not be coarser than 20 threads to the inch, for the beetles can work their way through cloth that is tight enough to exclude the root-maggot flies.

In unscreened seedbeds heavy applications of fine tobacco dust when the plants first begin to appear will often be found effective in protecting the

seedlings from severe injury. Tobacco dust is particularly valuable if applied to the seedbed when the soil begins to crack above the row as the young plants push through the ground. This treatment may be repeated at intervals of from four to five days to one week, depending on the amount of rainfall. Later the young plants may be kept thoroughly coated with a 4–4–50 bordeaux spray to which lead arsenate is added at the rate of 2 pounds to 50 gallons of spray.

Flea-beetle injury often may be greatly aggravated by the application of corrosive-sublimate solution for maggot control, and this treatment should be omitted where beetle injury is severe. In such cases, particularly if there is much stem injury, a suspension of calomel should be substituted for the corrosive-sublimate treatment for maggot control. In attempts to protect the cabbage seedbed from flea-beetle injury by the application of insecticides, the tendency is always to begin the treatment too late, and injury is often severe before even an experienced grower realizes what is happening.

CLUBROOT

(Caused by *Plasmodiophora brassicae*)

Plants affected with clubroot have yellowish, sickly leaves or green leaves that wilt on hot days. Young plants may die outright and older ones may fail to produce marketable heads. Roots of such plants are much enlarged and malformed. These malformations vary in size from very small swellings on smaller roots and rootlets to large clubbed masses, often cracked and furrowed on their surface, that later decay and give off bad odors.

The disease is caused by a parasitic slime mold that gains entrance through root hairs and injured roots. After the swelling of the roots is produced, the body of the slime mold is transformed into a mass of spores which are released into the soil upon the decay of the host tissue. The spores are disseminated by any means in which infested soil or soil water may be carried, and with contaminated manure. They are never carried on or in the seed. The organism is reported to be able to live in the soil for a period of at least seven years and to attack susceptible plants at any time during this period. Wet and acid soils are favorable for the propagation of the parasite.

Control

The eradication of weeds belonging to the mustard family, the choice of well-drained soil, the elimination of all seedbeds showing clubroot, and the practice of long crop rotations are sound recommendations of long standing.

FIGURE 3. CLUB-ROOT AS IT APPEARS ON THE SEEDLINGS IN THE SEEDBED

The seedbed is very important in the dissemination of the clubroot organism. For this reason the first real step in control is the location of the bed in an area where no diseased cabbage has ever been grown, where no contaminated manure has been applied, and where no infested soil can be washed. In past years the application of lime to the seedbed has been recommended if there was a possibility of clubroot infection. This advice has been withdrawn because it has been found that the lime in the seedbed merely hides the presence of the disease and does not protect the plants when they are removed from the infected soil and set into an acid soil in the field.

Fortunately corrosive sublimate will disinfect the soil about the roots of the seedling plant, and thus will hinder clubroot infection even when the slime mold is present. The new recommendation, then, is to treat all cabbage, cauliflower, and brussels-sprouts beds with corrosive sublimate as outlined under the control of cabbage root-maggot (page 7). If the disease promises to be severe, as many as five applications may be necessary in the seedbed, beginning as soon as the plants are through the ground, and repeating the application at weekly intervals.

It would be an impossibility to treat the plants in the field often enough with the mercury compound to control clubroot. But this is unnecessary

since hydrated lime has proved equally effective here when applied six or more weeks before the plants are set into the field. After the ground is plowed, enough hydrated lime, or quicklime if preferred, is scattered and harrowed in to produce an alkalinity slightly above neutral (pH 7.2). The county agricultural agent or the soils specialist by making tests can determine the amount to apply to any given field. In some cases only a few hundred pounds are necessary, while in others as much as three tons may be required. The points in the scale of alkalinity where infection is still abundant and where control is absolute are so close together that it is possible to apply almost enough lime and seemingly get no benefits from it. Therefore it is important that each grower have a test made of his soil, and then add enough lime to make sure that the soil reaction will be above the neutral point.

The type of lime used is important. It has been proved by experiments that only quicklime or hydrated lime can be used profitably in the control of clubroot. For some reason not yet explained, ground limestone or air-slaked lime will not stop the growth of the slime mold until the soil has been made too alkaline for good growth of cabbage. Consequently, ground limestone and air-slaked lime are not recommended. For the same reason spring rather than fall applications are advised. If hydrated lime is applied long before the crop is planted, the lime changes to the carbonate form which is ineffective in controlling the disease. The percentage of calcium in the hydrated lime is not important as long as it is not air-slaked. In other words, if lime with a high percentage of magnesium can be bought more cheaply, it can be used satisfactorily so far as it pertains to clubroot control.

CABBAGE WORMS

(*Pieris rapae* Linnaeus)

The velvety green caterpillars that attack the leaves of cabbage, cauliflower, and related plants are the larvae of the common white butterfly seen flying about the field from early spring till late autumn. The butterfly deposits its eggs singly on the undersurface of the leaves. The eggs hatch in about a week, and the young larvae feed at first on the underside of the leaf which they skeletonize. Later the larvae move about freely on the plant and eat out large irregular holes in the leaves, and often penetrate into the head itself. They become full-grown in from ten days to two weeks, and then transform to the chrysalis, or pupal, state in some sheltered place. In New York three broods develop annually.

Control

Fortunately cabbage worms are fairly susceptible to arsenicals. The poison may be applied either as a spray or a dust.

DUST FORMULA

Hydrated lime	75 pounds
Calcium arsenate or lead arsenate	25 pounds

The dust may be applied with a power duster or with a good hand duster that will give a cloud of dust to envelop the plant. In small plantings a cheesecloth bag may be used to distribute the dust by shaking it over the plant. It is not a good practice to sift the dust onto the plant with a perforated can or sifter. It is not so effective when applied in this way, and accumulations of the material on the leaves may cause injury. From the standpoint of efficiency, convenience, and economy, dusting is, in general, preferable to spraying in the commercial cabbage field, and is especially useful in the seedbed when the young plants become infested.

SPRAY FORMULA

Calcium arsenate or lead arsenate	2½ pounds
Soap	2 pounds
or	
Caseine spreader	½ pound
Water	50 gallons

The soap or caseine spreader is used as a sticker, to keep the liquid from forming into drops and running off the leaves at once. Liquid or semi-liquid soaps can be purchased on the market and are convenient to use. Soap chips are also easily dissolved. The hard laundry soaps, on the other hand, are difficult to dissolve and unless thoroughly in solution are likely to cause trouble by clogging the spray pump. They should be used only as a last resort.

Effective work can be done against the worms with spray if care is taken to apply the liquid thoroughly to all parts of the plant. A potato sprayer equipped with three nozzles to the row will give good coverage and may be used to advantage in large plantings.

In case the cabbage aphis is sufficiently abundant so that control measures are necessary, the arsenate can be added to the nicotine-lime dust used for the control of that insect.

CABBAGE LOOPER

(*Autographa brassicae* Riley)

The cabbage looper is a pale green caterpillar marked with two dorsal stripes and a white stripe on each side of the body. It crawls about with a peculiar looping motion like a measuring worm. The looper feeds on the leaves and bores into the heads much as does the common cabbage worms, but, being somewhat larger and a voracious feeder, the injury inflicted is often more severe.

The winter is passed in the pupal stage in the ground. Apparently there is a high mortality of the overwintering pupae, for the moths of the spring brood are rather scarce and the first brood of larvae attract comparatively little attention except occasionally in seedbeds on Long Island. There are said to be three generations annually in southeastern New York. The greatest injury is caused by the last brood of larvae, and this injury may be severe, especially on cauliflower.

Control

The cabbage looper is not so easily poisoned as is the common cabbage worm, owing largely to the fact that it is more active and can more easily avoid the poisoned foliage. The young larvae are more easily poisoned than are the older ones, and frequent applications of arsenicals are advisable to keep them killed off while small. If the first broods are kept under control, the last brood is not likely to be so numerous. This is important in the case of cauliflower, where it is not safe to use poison on the maturing heads. In general, the same materials may be used against the looper as are used against the common cabbage worms.

DIAMOND-BACK MOTH

(*Plutella maculipennis* Curtis)

Another caterpillar that sometimes injures the foliage of cabbage, cauliflower, and related plants is the larva of the diamond-back moth. This moth has an expanse of about 5/8 inch. Its name is derived from the form of the markings on the wings of the male, which, when the wings are closed, form a row of three diamond-shaped spots. The insect hibernates in the adult stage, the moths seeking shelter under cabbage leaves or other trash left in the field. The moths emerge in the spring and lay their eggs on the leaves. The eggs hatch in about a week, and the young larvae feed on the underside of the leaf. They eat into the leaf from beneath but do not cut holes all the way through. Later, however, the epidermis dies and falls out over these injured areas, leaving the leaf riddled with holes. When mature, the larva is about 3/8 inch in length, pale green in color, and its head is brownish yellow mottled with black. There are two or three generations annually in New York. Unscreened cabbage and cauliflower seedbeds are liable to infestation. In the field, cabbage is more likely to be injured early in the season while the plants are small, but in the case of cauliflower the late broods are usually the most destructive. On Long Island larvae and moths often remain abundant on both cabbage and cauliflower till November or early December.

Control

Dusting or spraying as for cabbage worm (page 17) will serve to keep the diamond-back moth under control.

CABBAGE APHIS

(*Aphis brassicae* Linnaeus)

In New York, cabbage, cauliflower, and related crops are subject to attack by two species of aphids. Except on Long Island most of the injury is caused by the cabbage aphis. On the Island, however, this species is of minor importance, its place being taken by the spinach aphis.

Under New York conditions the cabbage aphis passes the winter in the egg stage on leaves and stumps left in the field overwinter. These eggs hatch early in the spring, and the young develop on the sprouts sent out by the old stumps. In the first and second generations the lice are all wingless, but winged forms are produced later that migrate to other plants and there start new colonies. In this way cabbage and cauliflower plants often become infested in the seedbed.

The cabbage aphis is usually most abundant and destructive in seasons of drought. The lice become closely crowded together in dense masses, often covering large areas of the undersurface on the leaves. Their bodies are covered with a whitish waxy bloom that gives these masses a grayish appearance. The presence of the lice causes the leaves to curl, often producing deep pockets filled with masses of the insects. Badly infested plants are weakened, stunted, and may be killed outright. The formation of a good head is prevented and the size and the quality of the crop are greatly reduced.

Control

If the seedlings become infested in the seedbed, the tops should be dipped in nicotine solution, using 2 ounces of nicotine sulfate, ½ pound of soap, and 10 gallons of water. It is best to dip the plants shortly before planting them in the field. Do not dip the roots.

In seasons when conditions are favorable for the development of the aphis, the control of the insect in the cabbage field is likely to be difficult and expensive unless careful attention is given to the crop early in the season. The following method has given good control under commercial conditions even in seasons of heavy infestation. At the time the first cultivation would normally be made, or about a week or ten days after the plants are set out, the crop should receive the first application of a 4-per-cent-nicotine dust. In making the application, a hand duster should be used. The operator should take four to six rows at a time across the field, watching closely for aphis-infested plants. All affected plants and adjacent plants should be thoroughly and completely enveloped in a cloud of nicotine dust. The rotary type of duster has been widely used for this purpose, but some successful growers are changing to the bellows, or plunger type, because with this it is possible to cover individual plants

easily and quickly. Additional applications should be made at intervals of not more than one week until the plants have produced small compact heads. Most of the damage is done by the aphids before the cabbage head is formed, and to be effective the dust must be applied during the period previous to head formation. The saving in the cost of the dust made by using a hand duster more than offsets the expense of the extra labor required.

If these early treatments have been neglected and the infestation has become general throughout the field, it may be necessary to treat the entire crop. Such treatments, however, are expensive and the results often disappointing. Spraying with nicotine sulfate, 1 pint, and soap, 5 pounds, in 100 gallons of water, will kill a large proportion of the lice actually hit by the spray. It is, however, very difficult to reach the lice under the larger leaves and in the bud at the center of the plant. For this reason spraying is now rarely practiced in commercial plantings. Better results are obtained by the judicious use of nicotine dust. For the treatment of isolated plants early in the season, a 4-per-cent-nicotine dust may be justified by its greater killing power, but in most cases it is too expensive for use on the whole crop. In small plantings, the most effective and economical method of applying the dust is with a hand duster. Under such conditions a 3-per-cent-nicotine dust may be used at the rate of 40 pounds to the acre. In large plantings where it is necessary to use a power duster, better results can be obtained by using a 2-per-cent-dust at the rate of 60 pounds per acre. The dust is most effective against the lice when the temperature is high enough to liberate the nicotine quickly. The best time to apply the dust is on a hot afternoon when there is little wind. The efficiency of the operation can be considerably increased by using a canvas trailer as described on page 22.

THRIPS

(*Thrips tabaci* Lindeman)

Cabbage and cauliflower seedbeds, especially those on Long Island, are liable to infestation by thrips. This is the species also known as the *onion thrips*. These minute, elongate, yellowish insects attack the young plants soon after they come up. They first appear on the undersurface of the leaves along the midrib near the base. In feeding, the thrips rasp off the surface of the leaf and suck up the exposed juicy parts. The injured areas of the leaf present a dried, scarified appearance. When the injury is severe, the whole undersurface takes on a dirty brownish color. Injury from thrips is more likely to occur during periods of dry, hot weather.

Control

In the seedbeds thrips can be controlled by spraying with nicotine sulfate, ½ pint, and soap, 3 pounds, in 50 gallons of water or by dusting with 3-per-cent-nicotine–lime dust. Great care should be taken in making the applications so as to hit the thrips with the spray or the dust.

It is sometimes necessary to treat cauliflower plants for thrips after they have been set out in the field. A 3-per-cent-nicotine–lime dust can be used for this purpose. It should be applied with a power duster. To be effective, the duster should be equipped with a canvas trailer, 20 to 30 feet long, to confine the dust and cause it to settle on the plants. To be most effective, the dusting should be done when the temperature is high and when there is little wind. During the heat of the day, the plants are more limp than at any other time and are less likely to be broken off by the trailer. Spraying with nicotine sulfate and soap is sometimes resorted to and is very effective, provided the nozzles are arranged so that the underside of the leaves are entirely covered with the spray.

WHIP-TAIL, OR MALNUTRITION, AND TIPBURN

(Caused by unfavorable environmental conditions)

During certain seasons much whip-tail on cauliflower plants and tipburn on Danish Ballhead cabbage are observed; in some fields these diseases occur almost every year. The two troubles are related in that they both are produced by malnutrition.

Whip-tail on califlower manifests itself in a change of the normal green of the leaves to a light green or yellow between the veins and around the margins. The lower outer leaves are first and most severely affected. Later the upper inner leaves also show the abnormality. The injured leaves have a "quilted" appearance, being thicker than are the healthy ones and so brittle as to be easily crushed between the fingers. The seriousness of the injury to the plant may vary from the production of a full-sized head to the entire absence of one.

In tipburn of cabbage the tips of the leaves show brown or black margins. When the trouble is slight, only the margins of the outer, older leaves are affected; in a greater manifestation the outer leaves may be entirely dead, and the margins of the younger ones distinctly tipburned. In the more pronounced cases the whole plant is somewhat dwarfed and the head is not firm.

Control

No parasitic organism is connected either with the whip-tail or the tipburn. The trouble on the cauliflower may be produced in various ways, but commonly it is the result of an acid soil. When the disease occurs, a soil test should be made at once, and, if necessary, enough lime should be applied to get a soil reaction nearly neutral.

Figure 4. tipburn of cabbage

Even though lime is present whip-tail may affect the plants. It is then possible that the ratio of superphosphate and potash in the fertilizer is not correct. It has been found that where whip-tail seems to persist, the condition can be improved by decreasing the amount of superphosphate and increasing the amount of potash. For instance, if the formula

4–12–4, 4–16–4, or even 5–10–5 has been used, it may be well to try a 5–8–7 or a similar ratio. This is true particularly on farms that have been fertilized heavily each year with superphosphate until there seems to be a surplus of the material in the soil.

The tipburn apparently is not influenced much by the presence or the absence of lime, but it is increased by too great a supply of superphosphate. The 5–8–7 ratio seems to be the correct one to use where the tipburn is likely to be present. Only when growing Danish ballhead is it necessary to take this precaution, as early and kraut varieties of cabbage seem very resistant to the trouble. This recommendation does not suggest a change in fertilizer practices from that recommended generally by the horticulturists except when tipburn is severe enough to cause injury.

BEANS

A large proportion of the bean crop is destroyed by insects and diseases; therefore special care should be taken in procuring healthy seed, in taking precautions against the seed corn maggot, in long rotations to avoid root rots, and in spraying or dusting if the Mexican bean beetle or the downy-mildew is present.

ANTHRACNOSE

(Caused by *Colletotrichum lindemuthianum*)

The most characteristic symptoms of anthracnose are the black, sunken cankers on the pods. In the center of the lesions is a salmon-colored ooze. Similar lesions are found on the cotyledons of the young plants and on the stems. The most noticeable symptoms on the foliage are the blackened, dead portions of the veins on the underside of the leaf. The stems may be rotted off just as they emerge from the ground or the cotyledons may be destroyed. In either case the plant dies or becomes worthless. Later infections harm mostly the pods and their seeds. The mature infected seeds may or may not be discolored.

The organism causing the anthracnose is carried overwinter in the bean seed and in the diseased bean refuse left in the field or in the bean straw. It does not live long in the soil without beans and is not known to attack any weed hosts or other farm crops. When affected seeds are planted, the organism is pushed aboveground on the cotyledons, and from there it is scattered by the splashing and washing of rain, by insects, and on tools and clothing to all parts of the field. It grows through the pods and affects the new seed beneath the spot.

The disease is influenced much by the weather, being worse in rainy weather when the soil is wet, the humidity of the air is high, and the

temperature is between 63° and 75° F. Water must be present before the spores are liberated.

Control

Satisfactory control measures have not been found for all varieties of beans, especially those that are very susceptible. There are certain general recommendations that have proved beneficial, such as plowing under in the fall all diseased refuse, practicing three- to six-year rotations with other crops, using well-drained soil, refraining from cultivating the field when the plants are wet, and keeping the field free of weeds so that the plants will have good air drainage.

The principal control measure, however, consists in procuring healthy seeds or those that are resistant to anthracnose. Since the seeds in a pod without cankers are healthy, good seed can be obtained by picking the required number of healthy pods and saving the beans for planting next year's crop. If healthy stock of this type is planted in a field which is isolated from diseased plants, the resulting crop will be healthy.

Another method of procuring healthy seed is to have it shipped from some State or country where, because of weather conditions, the disease does not occur. At present nearly 90 per cent of the Red Kidney seed planted in the State comes from the Sacramento Valley in California or from Idaho. Certain areas in these two States are free from both anthracnose and bacterial blight. Much of the snap-bean seed is grown in Idaho, and is satisfactory from the standpoint of freedom from anthracnose, but mosaic is very prevalent, especially on refugee types. Some seed from Chile and also from Japan has been grown successfully, but at present there is no way of knowing whether the stock coming from these countries is diseased or healthy.

The most satisfactory means of control is the breeding or selecting of resistant varieties. This work is now being conducted on a large scale and promises to increase materially the resistant strains that already are available. The fact that there are in New York State at least three strains of the anthracnose fungus, each one differing in its ability to cause infection, complicates the matter of breeding and selection. A variety that is resistant in one locality may be susceptible in another where there is a different strain of the parasite. Nevertheless, much progress has been made. The Robust pea bean and other selections of this variety, the Wells Red Kidney, the Geneva, the York, the Perry Marrow, and the Nova Scotia Marrow, are among the varieties already in use, and others will be developed later.

Resistant varieties among the snap beans are still few in number, but there is much hope for the future in the large number of strains that now are being bred.

BACTERIAL BLIGHT

(Caused by *Bacterium phaseoli* et al.)

This disease in some of its symptoms may be confused with anthracnose, although all mature lesions are quite distinct. At least three prominent injuries are produced on an infected plant. Large brown blotches, often bordered by a yellow or reddish halo, are the distinctive symptoms on the leaf. The whole leaf later may die, and defoliation of the plant takes place. The second symptom is caused by a girdling of the stem at one of the lower joints, so that the whole plant wilts or falls over, and is sometimes known as *tip-over*. The third pronounced symptom is the canker on the pod. This rarely is circular as in anthracnose, and never is coal black or deeply sunken. The blight causes rather indefinite, water-soaked spots, usually with reddish margins, on the pods. At times a white or yellow ooze may appear on these affected parts. The infected seed may be discolored, but more frequently it is not.

The bacterial blight is caused by any one of six nearly related bacterial species and varieties whose life histories are practically the same. The organisms live overwinter in the seed and in the bean refuse in the field or in the bean straw. Their life histories, so far as the infection of the young plants and the spread of the disease are concerned, are the same as for the anthracnose fungus. In addition, the bacteria may enter the plant at any point and pass entirely through the water ducts without causing symptoms on the outside. Thus we speak of bacterial blight being *systemic* in nature. For this reason it is impossible to say whether beans are free from the disease even though the pods in which they grew looked perfectly normal.

Control

The general control measures for blight are the same as those given for anthracnose (page 25). But the problem of harvesting healthy seed or the breeding of varieties resistant to bacterial blight is far more complicated than when only anthracnose is concerned. Since the disease is systemic, the bacteria may enter the seed by way of the water ducts, and furnish no sign of their presence. Therefore pod selection for the control of blight is out of the question. Furthermore, there are no fully resistant varieties that can be used in breeding resistant strains.

As has already been shown in the discussion of anthracnose, a part of California and Idaho are free from bacterial blight. Inasmuch as kidney beans are the most susceptible to this disease, the seed is being shipped from these places. The one objection is that the Sacramento Valley does not produce so much seed as is required in the East, and occasionally a carload is received that evidently came from some other source, judging from the large amount of disease found in fields planted with this stock.

High-yielding strains of the kidney type are now being sent to Idaho, where they are grown in quantity and returned to this State. This does very well for kidney beans that are fairly resistant to mosaic; but the Refugee snap beans are very susceptible to mosaic, so until the Idaho growers develop a successful method of roguing seed plots, the snap-bean situation will remain unsatisfactory. Other varieties of the dry beans, as Robust Pea, Yellow Eye, and even Marrow beans, are resistant enough so that seed can successfully be grown locally.

Neither spraying nor seed treatment has proved effective in combating the anthracnose and the bacterial blight.

MOSAIC

(Caused by a virus)

The bean leaves affected with mosaic have irregular light yellow areas merging with dark green patches, producing the characteristic mottling, or mosaic, effect. The darker areas develop faster than do those having the yellow tinge, with the consequence that the leaf is much puckered, especially along the midrib, and the edges are cupped downward. The affected plant may have a sickly yellow color; nevertheless it remains alive until the end of the season. Early infected plants rarely bear any seed even though they may continue to blossom until autumn.

Mosaic is caused by a virus which lives overwinter only in the bean seed. The virus is carried from one plant to another by sucking insects, by rubbing one leaf against another, and in any other manner that sap from one plant may be transferred to the other.

Infection is favored by high temperature and high humidity at the time of inoculation.

Control

Among the field beans, the old type of pea variety was so susceptible to mosaic that its growing became a complete failure. It now is replaced entirely by the Robust Pea, which is immune or nearly so to the disease. The only other field bean that is much affected is the Medium. Since no resistant strains of this are available, some other variety must be employed in its place if the seed stock has become generally infected. All other field beans can be grown without much danger of loss from mosaic.

Among the snap beans the Refugee types are the most likely to be affected. These are rather generally grown by canners, and as most of the seed comes from Idaho it is not uncommon to find from 20 to 50 per cent infection in any given field. The only hope left is to procure the cooperation of the seed growers in Idaho, have them make use of

isolated seed plots from which all diseased plants are rogued, and in addition have the state pathologist index some of the most promising lots. The indexing consists in growing a few beans from each plant to make sure that the mosaic is absent and not just masked. The clean stock should then be used for planting fields that supply the eastern growers. Only the concerted action of the canners and growers in the State will cause the seed companies operating in Idaho to make an effort in procuring healthy stock.

A number of bean varieties are more or less resistant, and are being used successfully in developing new strains of the more desirable but susceptible varieties.

Seed treatment and spraying or dusting are of no value in the control of mosaic. It has been suggested that if seed is kept for several years, the virus will die and a healthy crop can be grown from this seed. This idea is erroneous, for the virus will remain active as long as the seed is alive.

SEED CORN MAGGOT

(*Hylemyia cilicrura* Rondani)

In years of excessive rainfall during May and June bean growers are likely to experience heavy losses from the destruction of the germinating seed by maggots. It often happens that the seed in whole fields is so badly injured that the crop has to be abandoned and the land refitted for some other crop. The flies of the seed corn maggot are very similar to those of the cabbage root-maggot. The spring brood of flies appears in May. They are attracted to newly plowed land, where they deposit their eggs in the soil. They prefer moist conditions for egg-laying, and the eggs are usually placed near decaying vegetation. Soil containing the decaying roots of clover or alfalfa is especially attractive to the flies for egg-laying. The eggs hatch in from two to four days into small white maggots. These make their way through the soil in search of food. They may subsist on decaying vegetable matter or germinating seeds. The maggots become full-grown in from nine to twelve days, and then transform to the puparium state in the soil. The flies emerge about two weeks later. There are two main broods of the flies annually; the first appears the latter part of May and the second in July.

If beans are planted in infested soil, the maggots attack the germinating seeds, feeding on the two seed leaves and often destroying the small bud between the two halves of the seed bean. If this bud is destroyed, the plant comes up in a deformed condition and is known as a *snakehead* or a *baldhead*. Plants injured in this way never produce a crop of beans.

Control

No practical way has been found to treat the seed or the soil with chemicals to prevent injury by the seed corn maggot. Much injury may be avoided, however, by adopting certain practices. The flies are attracted to freshly plowed ground for egg-laying. If the fields intended for beans are plowed and fitted in April or early May before the flies become abundant, the top soil will be dried out when they appear and the number of eggs deposited will be greatly reduced. Fields fertilized with barnyard manure just before planting are likely to harbor many maggots. It is, therefore, better to apply the manure to some other crop in the rotation and to use commercial fertilizer on the beans.

If the beans are planted shallow so that they come up quickly, serious maggot injury may be avoided. If the beans are planted with a drill, there is danger of getting them too deep in the soil. It is better to use a bean planter.

Much may be done to prevent injury by choosing a favorable time for planting. For the earlier maturing varieties it is sometimes a good plan to delay planting during periods of wet weather, but of course beans must be planted in time for them to mature before frost. In western New York the maggots are usually most abundant in the soiling during the last week in May and the first week in June. If the weather is cold and wet, planting at this time should be avoided.

FLEA BEETLES

Pale-Striped Flea Beetle (*Systena taeniata* Say.)

Red-Headed Flea Beetle (*Systena frontalis Fabricius*)

Two species of flea beetles often attack beans in New York. The pale-striped flea beetle is present in the fields from June till September, but the red-headed species does not appear in numbers till July. The injury to the young plants may be serious, especially if they are making a slow growth. The leaves become riddled with holes, turn yellow, and die.

Control

Flea-beetle injury to the young plants can be largely prevented by spraying with 1½ pounds of lead arsenate in 50 gallons of 4–4–50 bordeaux mixture or by dusting with 1 part of lead arsenate in 8 parts of hydrated lime. When the flea beetles become troublesome later in the season, the insecticides recommended for the control of the Mexican bean beetle (page 32) may be used.

DRY ROOT-ROT

(Caused by *Fusarium* spp.)

The root-rot affects directly only the roots of the plant; but the parts aboveground are stunted, may turn yellow and wilt, and usually die before the plants mature. If infection is only moderate and rather general, the plants may remain alive until harvest, but the whole field will have the appearance of being undernourished. The plants may be affected as soon as they emerge from the ground; usually, however, the trouble is more common on the older plants. When these are pulled up, the side roots are found to be rotted away, and the taproot has turned brick red and is hollow and dry. New side roots may be forming on the stem above the lesion.

The root-rot is caused by a fungus that lives in bean refuse and also in the soil for several years. It grows into the roots and up through the water ducts, thereby causing the plant to wilt. The fungus rarely fruits until the affected stems or roots are old and have started to decompose. The spores and the mycelium are carried into the soil on tools and horses' hoofs and in bean straw. They also may be splashed by rain or carried by floods. In spite of all these methods of dissemination, the fungus spreads rather slowly.

Probably the fungus affects no other crop. A Fusarium that occurs on the pea looks very much like the one on the bean, but the two are distinct so far as the hosts are concerned.

The root parasite is not influenced much by moisture, but is aided by a high temperature. Its best growth is at 86° F. A too alkaline soil also favors dry root-rot.

Control

When putting into practice root-rot control measures, it must be kept in mind that the pathogene is not seed-borne, but that it is strictly a soil organism. Since it is carried with the bean straw and since the heaviest soil infestation is found in the part of the State where winter lambs are fed on the straw, great care should be taken in manuring the different fields on the farm. The bean refuse should always be hauled to the part of the farm where beans probably never will be grown, or placed in fields where beans will not be grown for six or more years.

It is not known how long the root-rot fungus can live in the soil. It has been demonstrated, however, that where a six-year or longer rotation is practiced, the disease is held in check sufficiently to grow profitable crops. On the other hand, it has been shown that where the usual three-year rotation is practiced, root-rot increases until finally bean growing in those fields becomes an impossibility.

Aside from the correct disposal of the bean straw and long rotations a few general recommendations are made: Any diseased bean refuse left on the field should be turned under deeply by fall plowing. Beans should be planted only on well-drained, well-fertilized soil that is medium in the scale of alkalinity. Cultivation should cease as soon as root-rot once appears. If the base of the plant rots off and new side roots form above the lesion, the plant may live if the newly formed roots are not cut off by the cultivator. The more plant food available in the soil, the faster these side roots will form and the more chance there is for recovery.

Seed treatment and spraying are of no value in the control of root-rot. Unfortunately, also, no very resistant strains have been found from which suitable types could be bred.

MEXICAN BEAN BEETLE

(*Epilachna corrupta* Mulsant)

For many years the Mexican bean beetle has been known as a serious pest in the foothills of the Rocky Mountains from Wyoming southward into Mexico. In 1920, a small area in northern Alabama was found to be infested. From this new center the insect has spread rapidly northward and eastward until in 1927 it appeared in southwestern New York. It is now widely distributed throughout the State, and is especially injurious on Long Island.

The Mexican bean beetle passes the winter in the adult condition, often at a considerable distance from the bean field. The hibernating beetles can be found under piles of rubbish, in the drifted piles of leaves along fence rows, under the fallen leaves at the edges of woodlots, and in similar situations. The beetle is about ⅓ inch in length, oval in outline, strongly convex above, and pale yellowish to brownish in color. The eyes are black, and each wing cover is marked with eight small black spots arranged in three transverse rows. The beetles appear in the bean fields about the time the plants put out their first leaves. They feed on the foliage, mostly from the underside, eating holes in the leaves. The eggs, which are about 1/20 inch in length, oval in shape, and yellow in color, are deposited on end, in clusters of from 40 to 60, on the underside of the leaves. They hatch in from six days to two weeks, depending on the temperature. The larvae feed on the underside of the leaves, leaving the upper epidermis and a network of tissue and veins. The injured leaves dry up, and in severe cases the plant is killed. The larva passes through four stages in the course of its development and becomes full-grown in from three to five weeks. It is then about 2/5 inch in length, light yellow in color, and clothed with stout branched spines. When mature, it attaches the tip of its body to the leaf and transforms into a yellow pupa about ⅓ inch in length. The pupal period occupies about a week. The entire life cycle

is completed in from four to seven weeks, depending on the temperature. Under New York conditions two generations develop annually.

Control

The Mexican bean beetle can be controlled by spraying or dusting with an arsenical. Both magnesium arsenate and calcium arsenate have been found effective and safe when properly applied.

SPRAY FORMULAS

Magnesium arsenate	2	pounds
Water	100	gallons

or

Calcium arsenate	1½	pounds
Hydrated lime	3	pounds
Water	100	gallons

Sprays should be applied at the rate of about 100 gallons to the acre.

DUST FORMULAS

Magnesium arsenate	1 pound
Hydrated lime	5 pounds

To be used at the rate of from 12 to 15 pounds to the acre.

or

Calcium arsenate	1 pound
Hydrated lime	7 pounds

To be used at the rate of from 15 to 20 pounds to the acre.

The first application of spray or dust should be made as soon as the beetles appear and begin feeding on the bean leaves. The treatment should be repeated at intervals of ten days or two weeks. In both spraying and dusting, care must be taken to cover the underside of the foliage where most of the feeding is done.

On string or snap beans, where the pods are to be eaten, arsenicals should not be applied after the pods begin to develop. In such cases recourse may be had to commercial preparations of fluosilicates.

Arsenate of lead and arsenite of zinc are not recommended for use on beans because of the danger of injury.

GREEN CLOVER WORM

(*Plathypena scabra* Fabricius)

At intervals of several years there occur outbreaks of a slender, pale green caterpillar which riddles the bean foliage with large irregular holes and may even entirely defoliate the plants. The larvae of the green clover worm are destructive during July and August. The last serious outbreak of this insect was in 1919.

Control

On field beans the larvae can be readily controlled by applying any of the insecticides recommended for the control of the Mexican bean beetle (page 32). On podded string beans, where it is unsafe to apply an arsenical, the larvae can be killed by spraying thoroughly with nicotine sulfate, 1 pint in 100 gallons of water in which 5 or 6 pounds of soap has been dissolved.

BEAN WEEVIL

(*Bruchus obtectus* Say)

Although a serious pest in the South, the bean weevil rarely causes loss in commercial plantings in New York. Beans grown in gardens, however, may become heavily infested. Infestation by the bean weevil takes place in the field. The weevils lay their eggs in the pod, either through a small hole made by the female or through openings caused by drying and splitting of the pods. The grubs enter the bean when they are very small and become full-grown in the bean itself, and there transform to the adult, or weevil. In the case of the bean weevil the adults may emerge from the beans in storage, and may lay eggs among the dry beans, causing a secondary infestation. With the pea weevil, infestation occurs only in the field.

To destroy the weevils, the beans should be fumigated with carbon bisulfide in the fall. Place the beans in a very tight box or tight barrel. A cracker barrel or a sugar barrel is not tight enough. Use 1 ounce of carbon bisulfide to each bushel of beans, provided the beans nearly fill the receptacle. Place the carbon bisulfide in a shallow dish, such as a pie tin, on top of the beans, and cover the box or the barrel very tightly. Let fumigation continue for from twenty-four to thirty-six hours. To be effective, the work should be done where the temperature is at least 70° F. Carbon bisulfide is very inflammable and should not be brought near a fire. Do not smoke while fumigating the beans.

Beans containing living weevils should never be used for seed, because it is in this way that most of the insects gain access to the field. Even beans that have been fumigated should not be used for seed, for the percentage of germination will be low and those that do germinate will produce weak unthrifty plants.

DOWNY-MILDEW OF LIMA BEAN

(Caused by *Phytophthora phaseoli*)

The most conspicuous symptom of downy-mildew is the white downy mold in patches or completely covering the bean pod. The fungus grows through the pod wall into the bean. The whole structure finally shrivels, dries, and becomes black. Such black dried pods are common in badly

infested fields. The fungus attacks also the young shoots, the flowers, and the leaves. The tender branches and the flower-pedicels are distorted in shape and covered with the mold. The white mycelial weft appears very sparingly on the leaf, but the veins may be purplish in color, twisted, or otherwise distorted.

The time of incubation of the fungus is so short, the amount of inoculum so abundant, and the means for dissemination so nearly perfect, that within a few days it can sweep over a planting and leave nothing but blasted pods. Much of the early infection comes from the diseased seed. Within a few days fruiting bodies are formed on the surface of the pod, the stems, or the leaves, and the life history is repeated. Bees or insects collecting nectar carry the conidia from diseased to healthy blossoms. The wind, too, is an important factor in dissemination, as are flowing water and the splashing of rain.

Cool weather and moisture are favorable for the development of the downy-mildew, as is attested by the fact that in a rainy season the fungus grows even after the first fall frosts. It is most abundant in the districts where the night temperatures are low and the midday temperatures are relatively high.

Control

After studying the life history of the parasite, it is evident that long rotations, destruction of the diseased vines in the autumn, and the selection of seed beans from a healthy crop, are three important steps in controlling the mildew. When pole beans are planted, only two or three vines should be grown on each pole, and the hills should be far enough apart so that the vines at the top of the poles will not intermingle, permitting the dew and the rain on the foliage and the pods to dry quickly. As a supplement to the above-named control measures, spraying with bordeaux mixture, 4–4–50, is suggested. Since the disease occurs only during certain years and the epidemic cannot be foretold, it is necessary to spray each year. Each grower must decide whether the loss of his lima beans has been frequent enough to justify his use of bordeaux mixture. In New York applications seldom need to be made before July 15. Three or four additional sprayings are made at weekly or ten-day intervals.

PEAS

Nearly all the diseases of peas are root troubles that require for their control well-drained soil, early planting, and long rotations.

The planting of healthy seed is recommended for the control of blight, and dusting is advised for pea aphis when necessary.

BLIGHT

(Caused by *Ascochyta* and *Mycosphaerella*)

There are really three blight diseases that attack the pea, but as the organisms causing them are so nearly alike, they are treated here as one. The blight is a very serious trouble that may cause as much as a 20 per cent loss of the pea crop in the State when conditions are favorable for the fungi. This disease is found in all States east of the Mississippi River but is rare or entirely absent in the far-western States and in western Canada.

The disease produces black to purplish streaks on the stem. The lesions are more pronounced at the nodes, where they enlarge into brown or purplish irregular areas and may extend as high as 10 inches above the roots. The leaves become spotted in various ways. In some cases the spots are small purplish irregular dots, while at other times they are fairly large, almost circular, and may have concentric circles in them. On very susceptible varieties the whole leaf may shrivel and become dry. The spots on the pods are similar to those on the leaves, except that on the fleshy pods they are sunken and do not have concentric rings. When the disease is severe, the plant may not emerge from the ground or, if it does push through the soil, it may be killed soon after. Older plants do not succumb to the disease but their yield is much reduced.

Since the pod spot resembles very much the anthracnose of beans, the diseases on the two crops were considered identical at one time. They are now known not to be related. The pea blight is caused by three fungi, the life histories of which are almost alike. They are carried in the seed, and cause infection when the plant is emerging. Rains splash the spores to neighboring plants until a whole field is infected. The diseased seed and pea straw serve as means for the fungi to survive until the following season.

The optimum temperature for growth of the fungi is approximately from 75° to 80° F. A fairly rainy season is required for much dissemination of the disease.

Control

The general directions given for the control of pea wilt (page 39) apply equally well to blight. Well-drained soil, plowing under deeply in the fall all diseased refuse, and long rotations particularly are needful in the case of blight. But the most important measure of all is the procuring of healthy seed. All stock grown in the Eastern and Central States may carry the fungi. Therefore, it is strongly recommended that seed be bought from the far West where irrigation or dry-land farming does not permit the growth of the pathogenes. If this is impossible and the source

of the pea seed is not known, it is well to have the specialist at the state experiment station test the seed both for germination and percentage of disease. A small cost is attached to this testing. The grower can obtain the details of the plan by applying to his county agricultural agent.

Seed treatment has not proved successful.

Many varieties have been tested for resistance, but none of them have proved to be nearly immune. Some of the varieties that were much less affected than others were: Admiral 17.78, Advancer, Badger Special, Champion of England, Horal, Horsford, and Perfection. Where blight has been severe and western seed cannot be obtained, it might be possible to try some of the above-named varieties. The problem is complicated by the fact that some of these are very susceptible to wilt. Horal is the only one that seems valuable in combating both diseases.

BACTERIAL BLIGHT

(Caused by *Bacterium pisi*)

The bacterial blight of peas was first described in Colorado, but has since been found in most of the other States, and even in other countries. It apparently never has caused great loss in New York State, but seems to be increasing, and an occasional field may be found that has suffered much injury.

The disease is found on all parts of the plant above ground. The affected tissue of the stem assumes an olive-green to olive-brown color, and the stipules and the leaflets become yellowish or water-soaked. The trouble may show at any time in the growth of the vine. If the infection takes place before the peas are from 3 to 4 inches in height, the plants die and wither, leaving only missing spaces in the drill row. In older plants the infection has its source an inch or more aboveground, the lesion gradually extending upward on the stem until the top wilts; finally the whole plant may succumb.

The spots on the pod have a water-soaked appearance at first. Later the lesion may turn yellow or brown. When dried, the lesion has a papery texture.

The bacterium is carried over long distances on or in the seed, and in the field is disseminated by splashing rain and in diseased refuse. It enters through the breathing pores, and especially through wounds of young leaves and pods.

Control

No direct control measures are known. Since high humidity and high temperature favor the organisms, peas should be sown early in the spring in well-drained soil. No efficient seed treatmeent has yet been devised for

peas. Some attempt has been made to select resistant strains, but this also has not been very successful. The Alaska and the Telephone are two of the most susceptible; therefore where the bacterial blight has been serious, these varieties should be avoided.

PEA APHIS

(*Macrosiphum pisi* Kaltenbach)

The pea aphis is the most serious insect with which pea growers in New York have to contend. Fortunately it is intermittent in its attacks. The aphis is very sensitive to weather conditions, and years of great abundance may be followed by several seasons in which the insect does little or no damage. When abundant, however, it is capable of causing great damage and may even entirely ruin the pea crop over a considerable area.

The pea aphis is a rather large pea-green plant louse that harmonizes well in color with the plants on which it may be found. In addition to peas and sweet peas, it attacks clover, vetch, alfalfa, and sweet clover. Under New York conditions, except on Long Island, the pea aphis usually passes the winter in the egg stage on one of these plants; on Long Island the insect probably survives the winter, in part at least, as an adult or partly grown nymph. In the spring the first generations of the lice are produced on the winter host plants,—clovers and alfalfa. After the first generation part of the lice are winged and migrate to other plants where feeding conditions are more favorable. Some of these migrating lice find their way to the peavines. and there start colonies. Reproduction is rapid, and soon the stems become covered with the lice. The leaves, the blossoms, and the pods are soon attacked. Infested leaves become slightly thickened and curled; infested blossoms are blasted; and injured pods are stunted, deformed, and rendered worthless. Badly infested plants take on a sickly yellowish appearance and many be killed outright.

Control

In the case of canning peas sowed broadcast or planted in narrow drills, no practical method of controlling the aphis has been devised. On peas planted in rows to be hand-picked, the lice can be greatly reduced in numbers by spraying or dusting with nicotine preparations. The spray is more difficult to apply and usually gives less satisfactory results. Better results are obtained from dusting the plants with a 3- to 4-per-cent nicotine–hydrated-lime dust, using from 30 to 50 pounds per acre, depending on the size of the plants and the denseness of the foliage. The application should be made when the temperature is above 70° F. and when there is little wind. The dust may be applied with a tractor or power duster.

The nozzles should be set rather low and directed so as to envelop the plants in a cloud of dust. The effectiveness of the dust can be greatly increased by using a canvas trailer 30 feet in length, attached to the boom in front and allowed to drag over the peas as the duster moves forward. The trailer confines the dust to the vicinity of the plants and prevents its being blown away by the wind. When confined in this way, the fumes of the nicotine are much more effective in killing the lice. Furthermore, the trailer itself brushes many of the lice from the vines. They fall to the ground, and many are unable to regain the plants, especially if the sun is bright and the temperature is high. Dusting is much less effective when the plants are wet with rain or dew. It is not a good plan to apply the dust just before a rain if it can be avoided.

Nicotine dust is expensive, and one does not care to use it unless necessary. In order to avoid unnecessary or premature applications, it is best to wait till at least half of the plants are infested before making the treatment. The expense of dusting for the pea aphis may be considerably lessened by home-mixing the dust (page 97) or by using a self-mixing duster.

WILT

(Caused by *Fusarium* spp.)

In the past wilt and root-rot of peas have been so confused in their identity that it is difficult to know which is the more prevalent and injurious to the crop. It now is known that the wilt is widespread not only in this country but also in Europe, and in severe cases may cause the loss of almost the entire crop on a given farm.

Wilt usually is scattered in irregular spots over the field, the spots increasing in number and enlarging in size each successive year that peas are planted in the same soil. The disease affects the plant at the base of the stem. The first symptom is a reddish brown or chocolate-colored elongated or wedge-shaped lesion, which later becomes sunken. It can be differentiated from the root-rot by its darker color, and from the Rhizoctonia rot by its shape and the absence of a sunken, eroded surface. When the temperature is low, the stem may decay so that the root is partly or entirely separated from the top. Under higher temperatures the rot is not so pronounced, but the water ducts in the stem turn reddish brown in color and the plant wilts and may turn yellow, beginning at the lowest leaves. The taproot and any of the smaller roots also may have dark decayed spots on them. If conditions are favorable for the growth of the pea after infection, new roots may be put out above the upper lesions and thus the plant may be sustained so that it can bear at least part of a crop. In severe cases the whole plant dies.

At least ten different species of Fusarium have been described as causing the wilt disease of peas. The life history of all of them is essentially the same. It is not known whether any of them are ever carried in the seed. It is known, however, that the pathogenes are disseminated with infected pea straw in contaminated soil, in running surface water, and possibly also by means of wind. The organisms spread rather slowly within a field, but as they can live in the soil for a long time, short rotations where peas are grown permit them to multiply and finally to become generally distributed. They live overwinter in pea refuse and in the soil. If peavines are perfectly ensilaged, the parasitic fungi are killed; but when the vines are placed in a stack, most of those on the outside do not undergo fermentation and therefore serve as a source of inoculum when hauled to the field for manurial purposes.

Increase in soil moisture will accelerate the growth of the Fusaria, but the most important environmental factor is the soil temperature. At 47° F. one of the more common species does not grow; at 70° to 72° F. it grows at its best; and above 85° F. it almost ceases reproduction.

Control

Complete control measures have not yet been discovered. The grower, however, can do much by selecting well-drained soil which has not grown peas for at least four years. Contaminated pea straw should be placed on fields where peas are not expected to be grown. Burning the pea straw in the fall is a questionable practice, for it is wasting so much good green manure, and is not eliminating stubble that may have most of the infection. Plowing immediately after the harvest would be a far more economical procedure. Since temperature is important, the earlier the peas are planted, the less chance the soil has of becoming warm enough to favor infection until the plants are too large to be much injured.

In some cases it has been shown that fairly heavy applications of fertilizer will hasten the growth of the plants, and thereby enable them to overcome to a great extent the damage from the disease.

In addition to these general directions, there is the possibility of obtaining resistant varieties. The Horal, a strain bred in Wisconsin, has proved a satisfactory substitute where the wilt is very injurious on susceptible varieties. Among other more or less resistant strains are Green Admiral, Yellow or White Admiral, Rice's 330, Pedigreed Extra Early, Improved Surprise, Fasciated Sweet, and a selection of Alaska. It must be borne in mind that these strains and varieties, while resistant to some of the wilt Fusaria, may not be resistant to all of them, and there is the chance in some sections of having wilt on peas that proved resistant in other States. This, however, should not deter the grower in trying recommended strains if he has had much loss from this trouble.

ROOT-ROT

(Caused by *Aphanomyces euteiches* and others)

Pea root-rot is a very serious trouble in many sections where the crop is grown intensively. The various centers of infection are scattered throughout the field and gradually enlarge as the season advances. The disease causes a rotting of the roots and the parts of stem that are below the surface of the ground. The diseased roots first appear water-soaked, then become soft and light brown or yellowish in color. Finally the outer layers of host tissue decay and slough off, leaving only the slender central core. If one of the affected plants is pulled up from soft soil, the central core of the taproot and of some of the larger side roots will pull out as a long string. This peculiarity, together with the color of the lesion, helps to differentiate the root-rot from the wilt and from Rhizoctonia rot. If the plants are affected while still in the seedling stage, they usually lose their healthy color, slowly shrivel, and die. If the plants are half grown or more when infection occurs and conditions are good for pea growth, there may be no symptoms of the trouble aboveground. The plants may continue to grow normally and produce a crop.

The root-rot is caused by one, or possibly more, of the lower groups of fungi. If a diseased root is crushed and the tissue is placed under the microscope, hundreds of resting spores may be found. It is in this form that the fungus lives overwinter. In the spring these spores germinate either by means of a long fungous thread or by small spores that can swim about in the soil water. These, together with the summer spores, are extremely abundant and can be carried by running water, in soil that is moved, by splashing rain, and with diseased plant refuse. So far as is known, the fungus is never disseminated with the seed. When conditions are favorable and peas are grown successively on the same soil, or in short rotation, the pathogene grows luxuriantly.

The conditions most favorable for the Aphanomyces are: types of soil that hold the water readily, as stiff clay, or sandy soil underlaid with hardpan; plenty of rainfall; and fairly high temperatures.

Control

The general control measures are the same as those suggested for the pea wilt (page 39). In the long rotations, however, it must be kept in mind that the fungus can attack also vetch, alfalfa, sweet clover, and to some extent tomatoes, barley, and oats. The rotations could consist of such crops as potatoes, corn, cabbage, timothy, and the common clovers.

Early planting in well-drained soil is especially important in the case of root-rot, for, if the plants can be grown to half their normal size before infection takes place, the crop will continue to develop. In many parts

of the State the soil is much cooler and the possibility of rainfall is less during April than during May, June, and July.

No resistant varieties have been found, so that if the root-rot once becomes generally distributed over a farm, it would be well to grow other crops for a few years.

RHIZOCTONIA ROOT-ROT

(Caused by *Corticium vagum*)

Rhizoctonia is so common everywhere and affects so many plants that it is not surprising that under certain conditions it may cause serious trouble on peas. It affects mostly the base of the stem, where it causes a depressed reddish brown lesion that may or may not girdle the plant. It can be differentiated from the wilt in not producing a black or wedge-shaped lesion, and from the common root-rot by not leaving the central core of the root, which can be pulled out like a long string.

Rhizoctonia is very common on many hosts but probably only certain strains affect the pea. These live overwinter in the soil and in crop refuse.

The fungus requires wet weather and rather cool soil, so that there may be much Rhizoctonia root-rot in a year when there are many cold wet rains soon after the peas are planted.

Control

There are no direct control measures; crop rotations are helpful. During most years there should be little trouble from the disease, since the plants will outgrow much of the injury if the weather becomes favorable for pea production.

PEA WEEVIL

(*Bruchus pisorum* Linnaeus)

Peas grown in gardens are often found infested by a small white grub which, when mature, cuts out a hole to the surface, leaving only the thin outer hull over the opening. It then transforms to a pupa and later to a weevil. Under New York conditions most of the weevils remain in the peas till the following spring, and are often planted with the seed peas. The weevils deposit their eggs on the pods, and the young larvae bore through the pod and into the green peas. Only one larva is found in a pea. The pea weevil is unable to breed in dried peas, and there is only one generation a year. While peas grown in gardens are often heavily infested, the field crop usually escapes infestation entirely. Infested seed should never be planted.

Control

To kill the weevils, the peas may be fumigated with carbon bisulfide as described on page 33.

SPINACH

The nature of the spinach crop is such that very few satisfactory control measures for injurious insects and diseases are available at present.

SPINACH APHIS

(*Myzus persicae* Sulzer)

One of the serious enemies of spinach is a rather small yellowish green plant louse that often appears in countless numbers, especially in the fall. This insect is known also as the *green peach aphis* and the *green-fly* of greenhouses. It passes the winter in greenhouses, on its foodplants out of doors where the climate is mild enough, and in the egg stage on peach, plum, cherry, and apricot. In addition to spinach it attacks cabbage, cauliflower, eggplant, turnip, radish, kale, mustard, beet, pepper, horseradish, celery, rhubarb, and lettuce. It is often associated with the pink and green aphis on potatoes and tomatoes. It thrives also on a number of common weeds, including pigweed, lamb's quarters, dock, shepherd's purse, and many others.

As a spinach pest the aphis not only stunts the plants and greatly reduces the size and the quality of the crop but it also acts as a carrier for two serious diseases—yellows and mosaic. The potato aphis also aids in the dissemination of these diseases.

On spinach the aphis is likely to be most abundant in the fall when the cool weather slows up the activities of its parasites and its other insect enemies, but it may become troublesome at any time.

Control

The most practical method of controlling the spinach aphis on most crops is by dusting with a 2- or 3-per-cent-nicotine–lime dust. In the case of spinach, where the leaves lie close to the ground, it is necessary to have the nozzles of the duster carefully adjusted close to the ground and to use a canvas trailer to confine the dust. To satisfactorily control the lice, the application should be made when the plants are dry, when the temperature is above 70° F., and when there is little wind blowing. About 65 pounds of dust is required to properly treat an acre of spinach, using the ordinary type of nozzles and setting them as close to the ground as possible. A material saving in material may be obtained by using a special arrangement of nozzles in which they are allowed to drag directly on the ground, being connected to the outlet pipes by means of short lengths of rubber hose. With this arrangement and with the use of a canvas trailer, it is possible to reduce the quantity of dust to 40 pounds per acre and still obtain satisfactory results.

SPINACH LEAF-MINER

(*Pegomyia hyoscyami* Panzer)

The leaves of spinach, beets, and chard are subject to infestation by a white or yellowish maggot that mines in the tissue between the two outer layers, producing an irregular blotch. Several maggots are usually found in the same leaf, and often the blotches coalesce. The flies of the spinach maggot appear in the field in April or May. The female fly deposits her white, elongate eggs singly or in rows of two to five, side by side, on the underside of the leaves. The eggs hatch in from four to six days, and the young maggot works its way into the tissue of the leaf and starts to excavate its mine. The maggot becomes full-grown in a week to sixteen days. It then deserts the leaf and enters the ground, where at a depth of from 2 to 3 inches it transforms to a puparium. From two to three weeks later the flies emerge and soon lay eggs for another brood of maggots. There are three generations a year and a partial fourth in central New York.

The spinach maggot is most troublesome when attacking spinach, chard, and beets that are to be used for greens. It is especially objectionable in spinach grown for canning.

Control

Attempts to prevent infestation by the use of insecticides have been unsuccessful. It is possible, however, to grow the crop entirely free from maggots by screening the beds with cheesecloth. The cheesecloth cover is placed directly on the plants before egg-laying begins, and should be removed within a week before harvesting. The drawback to the use of a screen on spinach that is to be used for canning arises from the fact that the leaf-miner is not present every year and that to be effective the screen must be applied each year before it is possible to determine whether it will be needed or not. This makes the cost of the protector too high for the crop to be profitable. Screening may be practiced to advantage, however, on spinach to be sold fresh. On Long Island some growers avoid a bad infestation in spinach by growing the main crop late in the fall and very early in the spring.

DOWNY-MILDEW

(Caused by *Peronospora effusa*)

The downy-mildew, or leaf-mold, is prevalent wherever spinach is grown. It may be absent during certain seasons and then later destroy whole fields or, by appearing year after year, it may constantly menace the spinach crop.

According to the statements in literature, the parasite affects not only spinach but also swiss chard, lamb's quarter, and other plants belonging

to the goosefoot family, although none of the investigators seem to have conducted careful cross-inoculations.

The disease on the leaves is manifested by large—or sometimes small—spots, which are differentiated from the healthy tissue by their pale yellow color. Any part of the leaf or the entire surface may be included in the spotting. The diseased leaves are scattered on the plant, although the lower ones are first to be attacked. On the upper side of the leaf the spot is bare except in rare cases, while on the lower side the lesion is covered with a gray to violet-gray mold. The affected part finally decays or dries, and the whole leaf succumbs. In severe cases the entire plant is affected.

The downy-mildew fungus fruits abundantly on the underside of the leaf. The spores are splashed by rains, and possibly blown by wind, to other plants. Thus infection continues at a rapid rate if the weather is favorable for the growth of the fungus. The leaves that are killed later may be filled with thick-walled resting spores that can live over-winter. The following spring the new infections come from the parasite harbored in the old diseased refuse and also from the fungus that lives over in the seed.

The conidia, or spores, require a low temperature of 45° to 50° F. and plenty of moisture for best germination. They will continue to grow at higher temperatures. In other words, the mildew is most destructive during a rainy period when the nights are cool.

Control

There are certain general practices in alleviating the trouble, such as two- or three-year rotations, plowing under deeply all diseased plant refuse as soon as the crop is harvested, not crowding the plants too closely in the row, and in planting the seed in well-drained soil. If it were possible to select seed from a mildew-free field and to plant it in isolated fields, there would be no danger of the disease. It seems almost impossible, however, to be sure that the seed is not infected.

Since seed treatment and spraying or dusting have not given satisfactory results in controlling spinach mildew, the only other measure is to procure varieties resistant to the fungus. In various States, and on Long Island, selections have been made with very promising results. The only trouble at present is that a variety obtained from one firm may be resistant, while one with the same name from some other seed firm may be very susceptible. For instance, King of Denmark obtained from most companies is very severely infected, while that obtained from one company was only slightly affected. Doctor Guba of Massachusetts lists the following varieties, with name of firm, which showed least infection: Hot

Weather (Woodruff), Long Standing Savoy (Forbes, Woodruff), Long Season (Harris, Henderson), Long Standing Bloomsdale (Harris), and Long Standing Round (Sutton). Some of these might be tried where the disease has caused much loss. It should be remembered, however, that some of the varieties with these same names from other firms were infected heavily.

YELLOWS

(Caused by a virus)

Spinach yellows is known generally as *blight*, but *yellows* seems to be a better name since it describes the symptoms and is consistent with the term applied to a similar disease on other hosts. If the trouble once becomes established, it may cause very heavy losses of the crop.

The symptoms begin with some mottling, almost as in the case of mosaic, but as the disease progresses the symptoms become very characteristic. At first there is a slight yellowing of the young inner leaves, later they change to a yellow color, and finally die. The disease gradually spreads to the outer leaves, which in turn are changed to yellow. During this time the foliage curls and wrinkles. If the plant is affected when young, and it may contract the disease in the seedling stage, it remains much dwarfed. In the advanced stages of the disease, the plant dies.

The disease is due to a virus which is transmitted from diseased to healthy plants by means of potato and spinach aphids. The disease appears on the spinach within from twelve to thirty days after the feeding of the contaminated insect. Some infections are obtained even though the aphids remain on the plants for only five minutes. The insects are able also to inoculate five or more plants in succession after feeding once on diseased foliage. Molting of the aphid does not remove the contamination from its body. Furthermore, the virus may be transmitted from parent aphid to offspring for four or more generations.

The virus of yellows that affects other plants overwinters in the root sap of living perennial plants. This has not been proved true for spinach yellows. In the Southern States the aphids are capable of retaining the virus from one spinach crop until the next.

Control

In localities where yellows is general the only means of combating the trouble is the procuring of resistant spinach varieties. A cross was made between the Manchuria and the Savoy, and the new variety, which has proved resistant, is named *Virginia Savoy*. This should be planted instead of other types if the disease has caused much loss. Spraying or seed treatment is of no value as a direct control measure. Eradicating the aphis is helpful because it destroys the virus carrier.

MALNUTRITION

(Caused by unfavorable environmental conditions)

The spinach plant affected with malnutrition is dwarfed, and the foliage has yellowed tips and edges. The symptoms of malnutrition are somewhat like those of yellows or mosaic, but the disease may be distinguished by the following characteristics: The diseased leaves do not exhibit the normal savoyed effect of healthy leaves but are unusually thick, and the tissue is very brittle. The petioles and basal portion of the leaf show a marked red discoloration. In severe cases the whole leaf turns red. The plant dies prematurely.

Control

The control of malnutrition consists in liming the soil if it is too acid, or using an acid-producing fertilizer if it is too alkaline, and in applying a reasonable amount of a complete, well-balanced fertilizer. The soil, too, should be well supplied with humus and should otherwise be in good tilth.

BEET

The only beet trouble that causes much loss is beet girdle. The common potato scab may sometimes be prevalent, but this disease is discussed in detail in Extension Bulletin 135, "Potato Diseases and Their Control."

GIRDLE

(Caused by dry weather)

In some of the beet sections during 1929 and 1930, a severe injury occurred on the roots, the cause of which was somewhat debated. It is considered here as being caused by the unusually dry weather.

This injury consists of a circular dark spot that later may be sunken and may extend in the form of a girdle part way or completely around the entire root. The skin over the sunken area finally cracks and leaves the darkened tissue below exposed.

In some of the old dead areas Fusarium or Rhizoctonia occur, but it is almost certain that they are not the origin of the trouble.

The second possibility is fertilizer injury, due to irregular rainfall rather than to the use of excessive amounts. The only bases for this supposition are that, when a number of the beets are pulled up, fertilizer still clings to them; that the girdle is just below the surface of the ground where the fertilizer would naturally be collected; and that the girdle does not occur where two beets touch each other. This supposition has not been corroborated.

Figure 5. beet girdle

There is one remaining possibility, and all evidence seems to indicate that this is the correct solution. It has been known for a number of years that under certain conditions beet roots are very susceptible to drought injury and that the injury may form as a girdle just below the surface of the ground, as is true in the present cases. As added proof that this trouble is drought injury, it is rather certain that the loss in this State was much greater in the excessively dry summers of 1929 and 1930 than in any other past seasons. Secondly, during these two seasons there seemed to be a fair amount of rain until about July 1, after which the drought set in. The beets had a very good start in growing and then were suddenly checked. This would aid in the production of drought injury. Thirdly, the injury is generally more severe in the drier parts of the field than in the low land. Fourthly, a few records that were taken seem to indicate that the injury was more severe on the late-planted beets than on those that were planted early and received greater benefits from the early rains.

Control

The only control measures suggested are to retain the moisture of the soil by plowing under plenty of humus and to try in other ways to conserve the scanty rainfall during drought seasons.

LETTUCE

Lettuce diseases are very destructive, sometimes taking more than half of the crop. Unfortunately only general control measures are available. These include the removal of lettuce refuse, crop rotations, and eradication of weeds in the vicinity of the field.

BOTTOM-ROT

(Caused by *Rhizoctonia solani*)

Bottom-rot is by far the most destructive rot of lettuce in this State. The rot starts where the bottom leaves rest on the ground, and generally works up into the head, destroying first the blades of the leaves and less rapidly the midribs, but never rotting off the main stem of the plant. It is caused by the very common and widespread fungus known as *Rhizoctonia,* which attacks the plants from the soil, and which is very destructive when the lettuce leaves and the supporting soil remain moist. The parasite lives in the soil, on growing plants, and on diseased plant refuse. Its greatest period of development is after the healthy plants have been harvested and those with infection have been left to rot in the field.

Control

An important practice is long rotations with such crops as sweet corn, tomatoes, potatoes, cucumbers, radishes, beets, onions, and spinach. If a field becomes heavily infested with bottom-rot, it may be advisable to plant some cereal or hay crop for a year or two.

All vegetable crops, particularly celery, carrots, and cabbage, should be harvested promptly and removed from the field so that no molds can reproduce on them. As soon as the lettuce crop is harvested, all the unused plants or other lettuce refuse should be hauled a considerable distance from the field and placed in a composting heap. Even though this entails much labor, it has proved very profitable, since the fungi multiply rapidly on the old plants left in the field.

The moisture can be controlled somewhat by planting in well-drained soil, which receives frequent shallow cultivations, and by eradicating the weeds in the field and along the ditch banks so that there can be good aeration.

Excellent results have been obtained by the use of dust for the control of bottom-rot. A specific Dupont organic-mercury dust is blown under the plants by means of a special lettuce duster. One application of 25 to 30 pounds of the material is sufficient if made two or three weeks before the crop is harvested.

In greenhouses, the bottom-rot can be controlled by soil sterilization.

DROP

(Caused by *Sclerotinia* spp.)

The lettuce drop is mostly a greenhouse trouble, although it may be found also rather commonly in some fields. The rot begins on the stem near the surface of the soil, and rapidly spreads upward, killing the leaves in succession, until it reaches the heart of the plant. The dead tissue changes to a wet, slimy, decayed mass. The white fungus may grow over the entire plant, and also form many black, variously shaped sclerotia, which are the resting bodies. The parasite remains alive in the soil for a long time, and reproduces rapidly in the lettuce refuse left in the field or in the beds where it is grown. The same fungus attacks nearly all other kinds of vegetables, especially carrots, cabbage, and celery.

Control

The recommendations for the control of drop are similar to those for bottom-rot (page 48). Dusting has not yet proved beneficial.

TIPBURN

(Caused by unfavorable weather conditions)

Tipburn is one of the most destructive injuries with which lettuce growers have to contend. It is not severe on the early spring crop nor on the late fall one, but during the summer it may destroy the salability of nearly every plant in the field. On affected lettuce the edges of the leaves die and turn brown, in severe cases interfering with growth.

In a general way tipburn is known to be caused by weather conditions, chief of which is high temperatures, but the exact combination of conditions is still being debated. Formerly it was considered that the hot sun shining on the succulent, fast-growing tissue caused the injury, but it is now considered that the tipburn can originate even in the dark. It probably is a degeneration of the cells due to faulty respiration, which is brought about by high temperature.

Control

No definite control measures are known. A few precautions may help in reducing the loss in a crop. Deep and frequent cultivations when the soil is packed by heavy rains, sparing use of potash, and medium applications of superphosphate have reduced the amount of tipburn in certain fields. The Big Boston head lettuce is very susceptible, and it might be possible to substitute some other variety for the midsummer crop.

YELLOWS

(Caused by a virus)

Lettuce yellows is known also as *white heart,* because the center leaves become bleached and dwarfed. The head does not form even though the plant may continue to live. Young infected plants usually die. Old plants are not much injured by infection. The same disease is found on many weeds and cultivated crops. It is carried only by the leaf hoppers from one plant to another, and gradually is becoming one of the most important diseases of lettuce, asters, and other hosts.

Control

No control measures are known. If all the weed hosts for half a mile or more could be eradicated, the disease might disappear. Plants protected by a cheesecloth covering will remain healthy, but the expense of such a control measure is too high to be practicable.

MOSAIC

(Caused by a virus)

In mosaic, the lettuce leaves become mottled with yellow and green, ruffled, or otherwise distorted and dwarfed. The whole plant has a sickly appearance, and in most cases will not bear a head. The virus is carried in the seed and is transmitted by aphids and other sucking insects.

If disease-free seed could be obtained, mosaic could readily be controlled, but this has not yet been found possible.

DOWNY-MILDEW

(Caused by *Bremia lactucae*)

Downy-mildew is injurious mostly in the greenhouse or in coldframes when proper ventilation is not possible. The spots begin as lighter green areas on the upper surface of the leaves, and, as the lesions enlarge, the fungus fruits with white mycelium wefts in corresponding spots on the opposite side. The affected tissue later turns brown. The whole plant may be dwarfed and yellow. The fungus is supposed to live overwinter on wild lettuce. It requires a large amount of moisture for growth as well as cold nights and relatively warm days.

Control

The control consists mostly in correcting conditions favorable for the fungus. In coldframes where the temperature often is rather low, the air must be kept comparatively dry or the mildew is sure to spread. There should be some ventilation both day and night, to avoid high humidity. In greenhouses, if the night temperatures can be raised three or four degrees above normal for lettuce growing, the fungus will not thrive.

GRAY MOLD-ROT

(Caused by *Botrytis* sp.)

Gray mold-rot is of little importance outdoors, but is destructive occasionally under glass. Rotted plants are covered with a dirty gray, fuzzy mold. The disease attacks weak plants mainly, and in some measure can be avoided by obtaining a strong vigorous growth. In hotbeds and coldframes, special care should be taken to provide ventilation, so that drops of moisture will not collect on the inner side of the glass and drip back on the plants, for such moisture provides an excellent environment for the growth of the fungus. In greenhouses, if the night temperatures are lowered as far as is possible without injury to lettuce, the rot can be much reduced.

CUCURBITS

A seasonal system for the control of insects and diseases injurious to cucurbits begins with seed treatment for the leaf-spots and scab, followed by early dust treatments for the cucumber beetle. After these treatments, a regular schedule of spraying or dusting should be followed to control the beetles and the various vine and leaf diseases.

ANGULAR LEAF-SPOT

(Caused by *Bacterium lachrymans*)

Angular leaf-spot is very common and sometimes destructive in most of the older cucumber-growing districts. It affects cucumbers, certain gourds, and a few less-known plants of the same family.

The disease appears on the leaves, the stems, and the fruit. The spots on the foliage are irregular in shape, angular, and have a water-soaked appearance. In the presence of moisture, bacteria ooze from the spot in tear-like droplets, which dry down into a white residue. The water-soaked area later turns gray and dies. The drying and shrinking of the dead tissue may tear it away from the healthy portion, leaving large irregular holes in the affected leaves. The spots on the fruit are much smaller and nearly circular. When the diseased portion dies, the tissue becomes white in color and may crack open.

The bacterium causing the disease lives overwinter in diseased plant refuse and on the seed. During rains it is splashed from the soil to the stems and the leaves, and later to the fruit. After infection has once taken place, the organism is transferred readily on the hands and the clothing of the pickers. Infection takes place through the stomata, and, since they close during the night, most of the entrances by the bacteria take place in the early morning after daylight but before the dew or the

FIGURE 6. ANGULAR LEAF-SPOT ON A CUCUMBER LEAF

rain has evaporated. Inoculation may take place on the fruit just before picking. If such cucumbers are shipped long distances, much spotting may appear during transportation on fruit that apparently was healthy when picked. Frequent rains and a temperature of 75° F. are optimum conditions for the growth of the bacterium.

Control

The control methods are the same as those recommended for the control of cucurbit scab (page 53).

SCAB

(Caused by *Cladosporium cucumerinum*)

Scab occurs on cucumbers, muskmelons, and pumpkins. The affected leaves have water-soaked spots and become wilted. The stems also have slight cankers, but most of the injury occurs on the fruit, where at first there is an oozing of sap, as if there had been an insect sting. Later the spot increases in size and becomes a sunken cavity lined with an olive-green mold. The fruit finally may be destroyed by a soft rot.

The scab is caused by a fungus that lives over in old cucumber refuse, in the cracks about the greenhouse, and on the seed. It develops best in moist air with a temperature of about 77° F.

FIGURE 7. CANKERS ON CUCUMBER FRUIT CAUSED BY SCAB

Control

A few helpful suggestions include long crop rotations and plowing under diseased vines immediately after harvest. But the two important recommendations are seed treatment and spraying or dusting. The cucumber or the other cucurbit seed are tied loosely in a cheesecloth bag and are dipped in a corrosive-sublimate solution (1–1000) for five minutes. They are then rinsed in clean water and dried, or they may be planted while still wet. The corrosive-sublimate solution is made by dissolving 1 tablet in each pint of water required; or by dissolving 1 ounce of the powder in a little hot water and then adding enough cold water to make 7½ gallons. This should always be made up in wooden, glass, or earthenware containers, and never in metal ware.

The spraying on cucumbers is done with bordeaux mixture, 4–4–50, to which is added 2 pounds of calcium arsenate. Muskmelons and young cucumber plants are susceptible to injury, so the strength of the bordeaux mixture is reduced to 3–6–50. The ordinary copper-arsenate-lime dust 20–20–60 may be applied both to the cucumbers and the melons.

While the plants are small, a hand sprayer or duster may be more desirable than a horse-drawn machine, for, when the plants are far apart, much of the material is wasted on the ground between the hills. When the vines are large, a horse-drawn machine is preferable, for then it is

necessary to direct from three to six nozzles toward each row. The discs in the sprayer nozzles should have small openings so that the spray will be forced out as a fine mist. The dust nozzles, too, must be arranged in such a manner that every part of the plant will be covered.

Applications are made at weekly intervals, beginning as soon as the plants have their first true leaves, and continued, at least, until the first picking. If the crop is clean, then further spray or dusting is unnecessary. If, however, later applications are made, the material should be put on directly after the picking, so the fruit will not be spotted too much. The dust is applied when the vines are wet with dew. Vines are injured by much trampling, so care should be taken when spraying or dusting.

Workers on Long Island suggest that there is danger of vine injury when the usual strengths of spray are used, and have made the statement that it would be desirable in that area to use a 2–4–50 bordeaux mixture, especially when the vines are young.

LEAF-SPOT

(Caused by *Macrosporium cucumerinum*)

The leaf-spots on cucurbits at first are small, circular, and somewhat water-soaked. They enlarge rapidly, and may be recognized easily by the concentric rings and a definite margin on the upper side of the leaf. When enough spots are present, the foliage dies. The fungus lives over in the old plant refuse, and during the summer is splashed by rains or carried by tools from one plant to another. It may possibly be carried in the seed, though this has not been proved.

Control

The same control measures are suggested as for cucurbit scab (page 53).

STRIPED CUCUMBER BEETLE

(*Diabrotica vittata* Fabricius)

The striped cucumber beetle is without doubt the most important insect enemy of cucumber, melon, squash, and related crops with which the growers of New York have to contend. Not only does the insect cause direct serious injury to the plants from the feeding of the adults and the larvae but indirectly it causes even greater loss by aiding in the transmission of two serious plant diseases,—wilt and mosaic.

The cucumber beetle hibernates as an adult under trash and in patches of woodland, often at some distance from the fields in which the insect bred. The beetles emerge from hibernation early in the spring and feed for some time on the leaves and the flowers of various wild plants.

They congregate on cucurbit plants just as they are coming up. They feed on the leaves and gnaw holes in the stems near the surface of the ground. Many plants are killed outright and others are so badly injured that they make only a sickly growth. The most serious injury is usually done before the plant acquires three or four leaves, but the beetles are present and troublesome for a month or longer in the early summer. The beetles deposit most of their eggs in crevices in the ground near the base of the plants, but some are dropped at random wherever the female happens to be. The eggs hatch in about a week, and the larvae burrow into the underground stems or into the vines where they rest on the ground. Sometimes the main stem just below the surface of the ground becomes riddled with the burrows of the larvae, and the plant becomes seriously weakened or even killed. The larvae become full-grown in about a month, and the new crop of beetles appears in August or September.

Control

In garden plots and small plantings it is often practicable to protect plants by covering them with some kind of screen, but under commercial conditions the best results are obtained by dusting or spraying. Poisons are used in some spray applications, but only a few beetles are actually killed; the material acts as a deterrent, however, and drives them away. Early in the season dusting is the more practical method for controlling the beetles.

The most efficient dust for general use against cucumber beetle while the plants are small consists of calcium arsenate (1 pound) and gypsum (20 pounds). Dust applications can be made cheaply and effectively by means of a hand duster. Treatments should commence as soon as the beetles appear and should be repeated at intervals of a week for at least a month. The material should be distributed thinly and uniformly on the plants, since accumulations of the dust may cause leaf injury. The whole field should be treated in one day, for most of the beetles are not killed but are merely driven away from the plants. If only part of the field is dusted, the beetles will congregate in the area untreated. One hand duster will cover about 2 acres a day. The success of the treatment will depend on the uniformity and the thoroughness with which the leaves and the stems are covered with the dust.

Since the injury inflicted by the cucumber beetles as a carrier of the organism causing the wilt disease is even greater than that produced by its feeding on the plants, it is desirable to kill as many of the beetles as possible early in the season when they first congregate on the seedlings. This can be accomplished by the use of a 3- or 4-per-cent-nicotine–lime dust. The application should be made with a hand duster capable of quickly and completely enveloping the entire plant or hill in a cloud of dust. To be effective, the dust must be applied when the temperature

is 70° F. or above and when there is no wind. The dust is not effective when the plants are wet with dew or rain. A canvas cone attached to the outlet pipe of the duster is sometimes used to confine the dust around the plant and will increase the efficiency of the operation. After the first week or ten days, the control of the cucumber beetle is best effected by following a regular schedule of spraying or dusting as indicated on page 53.

TWELVE-SPOTTED CUCUMBER BEETLE

(*Diabrotica duodecimpunctata* Fabricius)

Closely related to the striped cucumber beetle is another species, yellowish green in color, with twelve black spots arranged in three transverse rows across the wing covers. The twelve-spotted cucumber beetle is usually not so abundant as the striped beetle early in the season and does not cause much, if any, injury by feeding on the seedling plants. It is of great importance, however, as a carrier of the wilt organism and mosaic virus.

Control

The spraying and dusting schedule indicated on page 53 will help reduce the number of beetles and will lessen the injury.

MELON APHIS

(*Aphis gossypii* Glover)

While several species of plant lice occasionally attack cucurbits, the greater part of the injury in New York is caused by the melon aphis. This insect is known by a number of names, including *cucumber aphis*, *cantaloupe aphis,* and *cotton aphis*. When attacking greenhouse plants, it is called the *black-fly*.

The melon aphis passes the winter, in the northern part of its range at least, in the egg stage on orpine, or live-forever. The lice develop on this plant early in the spring and then, when winged forms are produced, migrate to cucumber and melon. The time at which cucurbits are attacked varies considerably, but in New York it is usually rather late in the season. The lice congregate on the underside of the leaves, causing the leaves to curl downward, turn brown, and die. In severe infestations the vines may be killed or so injured that the crop is small and of inferior quality. Furthermore, the lice are instrumental in spreading certain plant diseases from plant to plant.

Control

The melon aphis is readily killed by spraying with nicotine sulfate, ¾ pint in 100 gallons of water in which 4 or 5 pounds of soap has been dissolved. To be effective, however, the spray must be applied so as to

hit the underside of the leaves where the lice are most numerous. This is rather a difficult thing to do under commercial conditions. It is more practical and less expensive to use a 2- or 3-per-cent-nicotine–lime dust. The treatment should be made on a hot quiet day, and care taken to envelop the plant with a cloud of dust, especially close to the ground.

BACTERIAL WILT

(Caused by *Bacillus tracheiphilus*)

The bacterial wilt is one of the more serious troubles of cucumbers, squashes, muskmelons, and pumpkins in the States east of Kansas and north of Tennessee. It rarely causes the loss of all the crop, but a loss of 10 to 20 per cent of the vines is not uncommon.

The disease starts on a single leaf, which gradually wilts and dies. The wilting spreads to the vine and finally to the whole plant. In certain squashes that are rather resistant there is no true wilting but a distinct dwarfing of the vine. Aside from wilting and dying or dwarfing there are no other typical outward symptoms. If, however, the affected stem is cut crosswise and some of the plant juice pressed against the finger, the juice will string out if the finger is withdrawn slowly. The sap of the healthy plant is watery and will not string. Drops of bacterial ooze may collect on the surface of the fruit. The roots are not affected directly.

The disease is caused by a bacillus that can live overwinter only in the digestive tracts of the striped and the twelve-spotted cucumber beetles. In the spring the parasite is deposited on the cucurbit leaves in the droppings of the beetles. It enters the host tissue through feeding wounds or directly through breathing pores, enters the sap ducts, and finally migrates to all parts of the vine. It is disseminated to other plants by insects and pickers.

The weather conditions seem to have very little to do directly with the increase or the decrease of the disease. Any environment that favors the feeding of the beetles, such as moderatly high temperature, naturally has a great effect on the number of infections later.

Control

A few plants in the garden may be protected by inclosing them in cheesecloth tents. Specially prepared sticks or wooden barrel hoops cut in halves are placed at right angles to each other, and their sharpened ends are inserted in the ground. The cheesecloth is stretched over the hoops and its lower edges are weighted with stones or soil so that no insect can crawl under the covering. Large plantings of cucurbits must be protected by insecticides and fungicides. The same dust or spray schedule is required as that suggested for the control of cucurbit beetles (page 55) and of scab (page 53).

It has been found that the American varieties, such as Chicago pickling, and other related pickling strains are much less susceptible than are similar varieties originating in Europe, such as Half Long Prolific, Oblong Green Pickling, King William, Short Green Parisian, and others. Where wilt has been severe, the American varieties should be chosen even though they are far from immune.

MOSAIC

(Caused by a virus)

Mosaic is one of the most threatening of all the diseases found on cucumbers and muskmelons. In some of the older sections the growing of these crops has become unprofitable, and the disease seems to be increasing in all the newer areas. If all growers do not take every precaution to eradicate the virus, the cucumber crop in New York State is almost sure to be much diminished unless resistant varieties can be found.

At least two distinct mosaics occur on cucurbits, although only one of them seems to be of a very virulent nature.

Slightly affected vines of cucumbers, muskmelons, and squash show the normal green of the leaf to be mottled with light yellow areas. The fruit, too, may be mottled, or have a much roughened surface caused by knobs of green, developing normally while the tissue between fails to grow. Sometimes the green color is almost totally lacking, and the disease then is known on cucumbers as *white pickle*. In severe cases the plants are yellow and very much dwarfed. Such plants bear little or no fruit.

The mosaic disease is caused by a virus in the sap of the affected plants. It lives overwinter in the seed of the wild or bur cucumber and in the roots of perennial plants, such as milkweed, catnip, poke-berry, ground cherry, or husk tomato. When these plants come up in the early spring, the cucumber aphis, the striped cucumber beetle, and the twelve-spotted beetle feed upon them. The mouth parts of the insects become contaminated with the virus which they carry to cucumber, muskmelon, squash, or pumpkin plants. Within five to ten days the new infections begin to show. The disease may then be transmitted from plant to plant in the field by insects or on the hands of workers harvesting the crop. It apparently is never carried in the seed, and does not live overwinter in the soil.

Control

In order to avoid the weed hosts that carry mosaic, the cucumber or melon field should be surrounded by cultivated crops and should not be near buildings, grainfields, hedge rows, vacant lots, or other places where the susceptible weeds grow undisturbed. The host plants—wild cucumber,

ground cherry, pokeweed, milkweed, and catnip—that grow in the cucurbit field or within 50 yards of its outer edge should be pulled up and destroyed. The field should be inspected for these weeds even before the cucumbers or the melons are planted, and the inspections repeated at frequent intervals during the growing season until there is no more danger from infection. This is not an easy task, but it is the only remedy until resistant varities are found. It would be a great help in weed eradication if the location of the cucumber or melon field were planned the fall before spring planting; for as soon as cold weather began crystals of some weed killer, as sodium chlorate, could be sprinkled along the fence rows or other places where clumps of the carrier weeds are known to occur.

If infected plants are found in the crop early in the season, it may be well to pull them up at once and remove them from the field. It is doubtful, however, if this roguing is of any value after the plants become nearly grown. Only that part of the plant which develops after inoculation takes place is injured much by the disease, so that if all early infections are avoided, the crop loss can be much reduced.

Seed treatment and spraying or dusting are of little or no value in mosaic control, except in so far as insect feeding is hindered.

Work is now under way in several States in developing resistant strains, which finally may be available.

DOWNY-MILDEW

(Caused by *Peronoplasmopara cubensis*)

The downy-mildew, or blight, may be destructive on Long Island if the weather conditions are right, but it rarely is found up-state. It affects not only cucumber, squash, pumpkin, and muskmelons, but also a number of other closely related plants.

Irregularly shaped yellowish spots appear on the upper sides of the foliage, usually on that nearest to the center of the hill. If the leaf is examined on the opposite side when dew or rain is present, the brown lesion will be covered, or at least bordered, by a purple fungous growth. The spots increase rapidly in size until the whole leaf withers and dies. In a badly diseased field it is not uncommon to find all the foliage dead near the center of the hill, with only the young leaves remaining at the tips of the vines. If fruit is being formed during the attack, it will remain dwarfed and have a poor flavor. Cucumbers so affected are known as *nubbins*. The fungus requires much moisture, accompanied by cool nights and warm days, for best development. It is not known how it lives over during the winter, nor is it known to be carried in the seed.

Control

Long rotations and plowing under diseased vines immediately after harvest are usually recommended as precautionary methods. The principal control measure, however, is repeated and thorough applications of bordeaux mixture or copper-lime dust. The spray or dust schedule for the control of downy-mildew on cucurbits is the same as that outlined for the control of cucurbit scab (page 53).

SQUASH BUG

(*Anasa tristis* De Geer)

The adult squash bug is about 5/8 inch in length, and is dirty brownish black in color above and brown, mottled with black, below. The adults hibernate in dry sheltered places and emerge in the spring to attack cucurbit plants as soon as they come up. The female deposits her rather large, brownish eggs in regularly arranged patches on the underside of a leaf. The eggs hatch in from six to fifteen days. When first hatched, the young bug is brightly colored; but, after the first molt, it becomes light dusty gray in color, almost white. The nymphs feed in colonies on the underside of the leaves, causing the leaves to wilt, curl up, turn brown, and die.

Control

While the squash bug is a serious and troublesome pest in the garden. it fortunately causes little injury in commercial plantings. In the garden, the following methods will be found of value in preventing injury. The number of bugs appearing on the plants in the spring can be greatly decreased by practicing clean farming and thus reducing the available shelter for the hibernating insects. After the crop has been harvested, the vines should be raked up and burned or converted to compost. This will prevent many of the later hatched nymphs from reaching maturity. The use of proper fertilizers and thorough cultivation will often enable the vines to withstand attack and outgrow the injury. After the ground has been fitted, but before the plants are up, many of the bugs can be trapped under pieces of boards placed on the ground. They collect under such shelter during the night. The boards should be examined every morning and the insects killed by hand. It will pay also to keep watch of the plants for some time after they come up and to hand pick all the bugs found on them. All egg masses should be destroyed by scraping them off with a knife or by crushing. When the nymphs are found, they too may be hand picked or killed by spraying with nicotine sulfate, 1 pint in 50 gallons of water in which enough soap has been dissolved to make a good suds, or the plants may be sprayed with one of the pyrethrum extracts. An upturned nozzle will be found convenient for reaching the young bugs on the underside of the leaves.

SQUASH VINE-BORER

(*Melittia satyriniformis* Hübner)

One of the most troublesome insect enemies of squash and pumpkin is the squash vine-borer. The insect also attacks cucumbers and melons, but so far commercial cucumber plantings in western New York have escaped noticeable injury. The borer is the larva of a day-flying moth which, when on the wing, is easily mistaken for a wasp. The moth deposits her eggs on the stem of the plant, and the young borer penetrates the vine and burrows through the stem, usually towards the base. The burrows of the larger larvae are usually wet, slimy, and partly filled with excrement; decay often ensues and hastens the death of the vine. When mature, the borer leaves the stem and enters the ground an inch or two for pupation. On Long Island there is one brood and a partial second, while farther north there is only one generation a year.

Control

No really satisfactory method of controlling the squash vine-borer has been devised. It may be held in check, however, by practicing such of the following methods as are warranted by the severity of the outbreak and by other local conditions. Since the insect passes the winter in the ground, it is not a good policy to grow squashes in the same field year after year. If for any reason it is necessary to raise successive crops of squashes on the same ground, the land should be harrowed in the fall, to expose the cocoons, and then plowed deeply the following spring. The vines should always be collected and destroyed as soon as the crop is harvested, in order to prevent the late caterpillars from reaching maturity. If all the growers in a locality would cooperate in the early destruction of the vines, the number of moths that would normally appear the following spring would be greatly reduced. Sometimes much injury may be avoided by late planting and heavy fertilization to promote rapid and heavy growth. In some localities the use of early squashes as a trap crop has been attended with success. A few early squashes, such as crooknecks, are planted early around the field and between the rows of the late varieties. The moths will deposit their eggs on the early squashes, and the main crop, coming up later, will escape the greater part of the infestation. As soon as the early squashes are harvested, or sooner if they crowd the main crop, the vines should be pulled up and burned or composted, in order to kill the borers they contain. After the borer has once entered the vine, there is nothing to be done but to cut it out with a knife. If care is taken to make the cut lengthwise of the stem and if the vine is immediately covered with earth at the injured point, the wound soon heals and the vine continues its growth. Some growers

make a practice of covering the stem with earth 2 or 3 feet from the base, in order to make the vine throw out a new root system which will sustain the plant in case the main stem is injured at the base.

Experiments have indicated that nicotine sulfate is effective in killing the eggs. To be effective, however, 1 part of the nicotine in from 100 to 250 parts of water must be used, depending on the method and the thoroughness of application. Four treatments should be made at weekly intervals. This makes the method too expensive for use on a large scale.

ONION

The onion smut is controlled by the application of a fungicide at seeding time, and the maggot is held in check by spraying. The injury to this crop caused by the other diseases and insects may be reduced by crop rotation, destruction of onion refuse, careful handling of the bulbs, and proper storage conditions.

SMUT

(Caused by *Urocystis cepulae*)

Onion smut is rather common in New York State on the older muck areas. It is not present in the Southern States where the temperatures are high.

The presence of smut is first indicated by one or more dark spots at different heights in the leaves of the seedlings. These are more or less opaque when the plant is held up to the light. After a time, usually while the second leaf is developing, longitudinal cracks begin to appear on one side of these spots. These crevices widen and show within a dry fibrous mass which is covered by a black, sooty powder, made up wholly of the ripened spores of the fungus. These spores are blown or washed into the ground. Similar smut lesions may show in the second leaf and in those formed subsequently. Plants thus diseased usually die early, especially if the soil is dry. Some may make considerable growth and survive even up to the time of harvesting. In such specimens the smut shows itself by black elevations upon the bulb, running down to the very base and extending upward into the leaves.

The cause of onion smut is a fungous parasite which lives from year to year in the soil. Instances are known in which onions planted in a smut-infested field after an interval of twelve years became severely affected by this disease. Only onions grown from seed are subject to this disease and these are not attacked by the parasite except in the very young stages. Onions grown from sets or transplanted from soil free from the organism are not subject to the smut.

Control

Because the fungus persists for such a long interval in the soil, crop rotation is of little value in reducing the amount of smut in a field. Since onions can be attacked only in the seedling stage, sterilization of that soil in the immediate vicinity of the germinating seed and seedling plant affords a satisfactory and practical means of control.

Formaldehyde solution applied in the furrow with the seed at the time of sowing will effectively control onion smut. A solution of the desired strength is made by adding 1 pint of commercial formaldehyde to 16 gallons of water. This solution should be applied at the rate of 200 gallons to the acre when the soil is moderately dry. If the soil is wet, the formaldehyde is diluted to 1 pint in 10 gallons of water and is applied at the rate to 125 gallons to the acre.

A watering device is attached to the drill, and this discharges the liquid in the open furrow either behind the seed or directly with it. Tanks of three-gallon capacity for this purpose can be attached readily to a seed drill. A stopcock and tank outlet of $\frac{5}{16}$-inch bore, when opened wide, will make approximately the 200-gallon application to the acre; the rate of flow varies somewhat with the arrangement of the tank and the size of the conducting tube used. A properly equipped drill should discharge when stationary 1 gallon of the solution every 50 seconds. A more even distribution of the formaldehyde is obtained if the top of the tank is made air-tight and the air is brought in through an outside pipe that has its lower opening at the bottom of the tank and its outer end extending upward to a position even with the top of the tank.

No dust applications in New York State have yet been found satisfactory for the control of union smut.

ONION MAGGOT

(*Hylemyia antiqua* Meigen)

While present throughout the State, the onion maggot is most destructive on the muck soils of western New York. Here a large acreage of onions is grown year after year on the same land, and the insect is able to maintain itself in excessive abundance.

The adult of the onion maggot is an ash-gray fly about 1/5 inch in length and closely resembles the adults of the cabbage root-maggot and of the seed corn maggot.

The onion maggot winters in the puparium stage in the soil of onion fields or under piles of onion refuse and cull onions that were discarded at harvest. In New York the flies begin to emerge about the middle of May and continue to appear for about a month. Flies coming from refuse

piles begin somewhat earlier than in the open field and emergence continues for a longer period. Not only are refuse piles dangerous centers of infestation because of the large number of flies that they produce but also because they materially lengthen the period during which the flies emerge.

The flies do not begin egg-laying as soon as they emerge but wait from one to three weeks before the first eggs are deposited. This is known as the *pre-oviposition period* and averages about 10 days in length. The flies deposit their smooth, white, elongate eggs in crevices in the soil around the plants or in the axils of the leaves at the base of the plant. The eggs hatch in from two days to a week, depending on the temperature. The feeding habits of the maggots vary somewhat with the size of the plants attacked. In young plants the maggots are to be found both in the bulb and in the stem aboveground. The bulb is often completely hollowed out, leaving only the outer sheath intact. The maggot requires from fifteen to twenty days to reach maturity. It then leaves the onion and burrows a short distance into the surrounding soil, where it transforms into a pupa within the hardened larval skin, or puparium. The puparium is chestnut brown in color and about 1/5 inch in length.

A second brood of flies emerges during July and early August, the greater number appearing during the last half of July. Usually a small partial third brood of flies appears late in the season. Sometimes newly hatched larvae of the last brood have just entered the bulbs at harvest time. These may develop in storage, causing serious loss.

Control

The most satisfactory and practical method of controlling the onion maggot is by spraying with a 2-per-cent lubricating-oil emulsion. For this purpose two types of oil have been extensively tested, Red Engine and paraffin lubricating oil. The former is more widely used and on the whole more satisfactory than the lighter paraffin oil.

Lubricating-oil emulsions suitable for spraying onions can be purchased ready for use when diluted. For the average growers these commercial emulsions are more satisfactory and economical than are the home-made preparations. Considerable saving, however, can be effected by the large grower or by a number of growers cooperating by purchasing the necessary ingredients and making the stock emulsion on the farm.

It has been the practice to dilute the stock emulsion with 4–4–50 bordeaux mixture, and this combination has given the most consistently satisfactory results. The oil emulsion can be used without the bordeaux, however, and good control obtained. The combination of the oil emulsion with bordeaux seems to increase the efficiency of the mixture somewhat;

the bordeaux provides a stabilizer in case extremely hard water has to be used, and thus prevents a breaking down of the emulsion.

Some of the commercial emulsions found on the market contain about 66 per cent of oil, but other brands have a higher oil content. To obtain a 2-per-cent emulsion, enough of the commercial stock emulsion should be used to supply 2 gallons of actual oil for each 100 gallons of the spray mixture. If a 66-per-cent stock emulsion is used, 3 gallons of this emulsion is diluted with enough water to make 100 gallons. With stock emulsions having a higher oil content, a corresponding smaller amount is required.

For preparing the homemade emulsion, a large orchard sprayer will be found most convenient. The spray tank should be thoroughly cleaned of all spray deposits. Not more than 200 gallons of emulsion can be prepared in a 300-gallon spray tank because of the foaming of the liquid. The materials for each 100 gallons of stock emulsion are combined in the following proportion: 66 gallons of lubricating oil, 33 gallons of water, and from 50 to 100 pounds of potash fish-oil soap. The amount of soap required will vary greatly with the hardness of the water and the kind of lubricating oil used. Red Engine oil is more difficult to emulsify than is paraffin oil and requires more soap. If the emulsion is to be applied merely diluted with water, it is important to have the emulsion stable, and an adequate quantity of soap should be used. If the emulsion is to be used in combination with bordeaux mixture, the minimum amount of soap indicated will usually be found sufficient.

To make the emulsion, the proper amounts of the materials are placed in the spray tank, and the mixture is pumped back into itself through the spray gun for from 10 to 15 minutes. After this is finished, the emulsion can be transferred to storage containers through the spray gun, using enough pressure to break the liquid into a fine mist. For use, 3 gallons of this stock emulsion should be diluted with 97 gallons of either bordeaux mixture or water, preferably the former.

In spraying for the onion maggot, the object is to apply the spray in such a way that the soil immediately around the base of young plants will be uniformly moistened by the emulsion. Applied in this way the oil kills the eggs and the young maggots as well as acting as a deterrent to the flies. In order to wet the soil uniformly, it is important that the spray be applied with a pressure of about 50 pounds. Since the flies are active over a long period, several applications are necessary during the early part of the season to insure a satisfactory control of the insects. The first application should be made when the flies first appear in the field and begin to deposit eggs. This is usually when the young onions are about 1 inch high and when the first leaf pulls out of the ground and the

PHOTOGRAPH BY HUGH GLASGOW

FIGURE 8. ORCHARD SPRAYER EQUIPPED WITH MULTIPLE-ROW BOOM AS USED IN ONION-MAGGOT CONTROL

plant begins to straighten up. Ordinarily three applications are needed at intervals of a week or ten days, and in some cases one or two additional sprays may be worth while. The first two sprays are indispensible, and the proper timing of these applications is of the utmost importance.

In plantings of less than an acre, the emulsion may be applied with a hand sprayer. For larger areas, the most convenient way to apply the spray is by means of a small garden tractor equipped with a special spray attachment.

Instead of using the tractor sprayer some growers prefer to use a multiple boom, equipped with a nozzle for each row and carried by two men. The power is furnished by a large orchard sprayer which is driven along the driveways at the edge of the onion field. When this method is fol-

PHOTOGRAPH BY HUGH GLASGOW

FIGURE 9. THE TRACTOR CULTIVATOR EQUIPPED WITH SPRAY ATTACHMENT FOR ONION-MAGGOT CONTROL

lowed, it is not necessary to prepare a stock emulsion; the oil is emulsified in the spray tank and used at once. On the basis of 300 gallons of the finished spray mixture, the equivalent of 25 pounds of copper sulfate and 35 pounds hydrated lime should be added to 20 or 30 gallons of water in the bottom of the spray tank. After this is thoroughly mixed by the agitator, 6 gallons of the lubricating oil should be added and the concentrated emulsion sprayed back into itself through the spray gun for about 10 minutes. Then the spray tanks should be filled with water and the spraying commenced. It is a good plan to keep the sprayer running till the tank is empty. To avoid injury, it is necessary to remove the concentrated oil emulsion from the pump, the pipes, and the boom before starting to spray the onions.

Although timely and careful spraying is the most important operation in onion-maggot control, other measures should not be overlooked. Piles of cull onions around packing sheds and along the edges of fields serve as breeding centers for the onion-maggot flies, and they should be disposed of by burying, burning, or hauling away to a considerable distance from any land to be planted to onions the following year.

In special cases, such as bunch onions, where it is feared that the oil will disfigure the tops, calomel applied to the seed at planting time will be found a useful alternative. The onion seed is first moistened and then thoroughly worked up with the dry calomel. About 2 pounds of the calomel will adhere to 1 pound of the seed. If such treated seed is sown thickly, as for bunch onions, the danger of maggot injury will be greatly reduced. Unfortunately this method is not applicable to field onions that are planted more thinly. Finely powdered calomel suitable for this use should cost in the neighborhood of from $2.00 to $2.50 a pound.

ONION THRIPS

(*Thrips tabaci* Lindeman)

Onions are subject to injury by a small yellowish or brownish thrips which punctures the epidermis of the leaves, sucks out the juices, and causes the plants to turn whitish, wilt, and fall down. While the insect causes important losses in all parts of the State, it is more destructive in southeastern New York than elsewhere. Onions grown from seed are more severely injured by the thrips than are those grown from sets, but the latter are usually heavily infested and serve as breeding reservoirs from which the insects spread to seed onions.

The onion thrips passes the winter in both the adult and the nymphal stages on onion plants left in the field and in rubbish on the ditch banks and along the edge of the fields. The adult thrips is only about 1/25 inch in length, light yellow to brownish in color, and provided with two pairs of slender wings that are fringed with long hairs. The female inserts her minute whitish eggs into the tissue of the leaf. The eggs hatch in from a week to ten days. The nymph pass through two stages while feeding on the plants and then enters the ground, where it passes through two more immature stages before becoming adult. The life cycle is completed in about twenty-six days. There are five or six generations annually, and breeding is continuous until stopped by cold weather.

A careful examination of infested onion plants at any time during the summer will disclose the presence of four stages of the onion thrips; namely, egg, first- and second-stage nymph, and adult. Both the nymphs and the adults feed on all parts of the leaves but are to be found in large numbers hidden under the sheath at the base of the leaves or between the

young leaves at the center of the plant. In feeding, the thrips puncture the epidermis of the leaf with its sharp, needle-like mouth parts and then sucks out the juices of the plant, killing the cells and causing them to turn whitish. When the infestation is severe, the leaves assume a dirty white or bleached appearance. Badly injured plants wilt, and the leaves fall over on the ground; the bulbs do not make the proper growth, and the crop is of small size and inferior in quality. The plants are most susceptible to injury during July and August when they are making their most rapid growth. The thrips is most destructive in years of drought and on onions grown on poor or poorly cultivated soil.

Control

Many onion thrips can be killed by applications of nicotine sulfate, either as a spray or a dust, but attempts to control it by these means have usually been unsuccessful because a large proportion of the thrips are under the leaf sheaths where they are protected from the action of the insecticide. For this reason spraying or dusting onions for thrips has never been a profitable operation. Until some better method of direct control is discovered onion growers should give careful attention to other means of reducing the severity of the infestation or delaying it till the plants are larger and more able to withstand attack. The number of hibernating thrips should be reduced to a minimum by burning over ditch banks in the fall or the early spring. Set onions should never be grown near seed onions because they may be an important source of infestation for the latter. The thrips get an early start on the sets and are very abundant on them when they mature and are pulled in late July or early August. They then migrate in great numbers to the seed onions and augment the injury caused by the thrips already present. The farther set onions are grown from seed onions, the better.

DOWNY-MILDEW

(Caused by *Peronospora schleideni*)

Onion mildew is very common in the State, and during wet, cool weather may become very destructive.

It seldom occurs early in the growing period of the plant; the first symptons on the leaves are ordinarily not discernible until the bulbs begin to form. The infection starts on one or a few isolated plants which serve as centers from which the inoculum is disseminated. Even before there is any discoloration of the foliage tissue, the fungus, on wet mornings or during a rain, forms a purplish mold over the surface of the leaf. As the infected spot enlarges, the whole leaf takes on a water-soaked appearance, then later turns yellow, and on drying may become white. Soon after

infection takes place, the leaf, because of the weakened tissue, may drop over, shrivel, and become black with mold.

The pathogene lives overwinter as mycelium in the seeds, onions bulbs, and sets, and as oospores in the old diseased foliage. If infected seeds, sets, or large bulbs for seed are planted, the mycelium grows up with the foliage, and, when favorable weather conditions prevail, the fungus fruits.

The parasite, being a downey-mildew, requires plenty of moisture with rather cool nights and relatively warm days. When such a combination of weather occurs, an epidemic may be expected wherever the fungus is present.

Control

Since the parasite lives in the old onion refuse, a rotation of crops extending over three or four years is the first recommendation. The second is that of having well-drained soil, eliminating or avoiding wind barriers, as woods, hills, and weeds, and in every other way aiding the tops of the plants to dry during the day. The third is the burning of diseased-onion refuse. The fourth recommendation is the obtaining of disease-free seeds, sets, or seed bulbs. This may not be possible at present, but if greater care is taken in growing sets, and especially if each consumer knows the source of his seeds and sets or grows them himself, he may be able to obtain disease-free stock.

Sometimes it is possible to select varieties that have small tops, which dry quickly and do not mildew so severely as do those with large tops. As an instance of this, the small-topped Mountain Globe Danvers do not blight so badly as do the large-topped South Port yellows.

Much has been written regarding the spraying of onions. At best, it is a difficult task, and only under certain conditions is it profitable.

NECK-ROT

(Caused by *Botrytis allii* and others)

Neck-rot is known to be serious on mature onions and on sets, and probably is present in every part of the world where onions are stored. In poor storage places the loss may comprise the total crop. In some years the fungus also causes blasting of the onion flowers or injures the viability of the seed.

Neck-rot is confined to varities of the common onion. The white onion is much more susceptible than is either the yellow or the red type. The onion with a thin neck, which dries easily, is less susceptible than is another of the same variety that is thick-necked.

The disease seldom occurs on the bulbs while they are in the ground, although the fungus may attack injured leaves even when the plants are

young. The lesions on the bulb appear as sunken dried-out places about the neck, which finally may involve the whole bulb. In a cross-section the scales appear as if they had been cooked. The tissue is soft and of a brownish color. Between the scales is a gray mass of mycelium, and on the dried parts of the scales small black sclerotia begin to form. On the outside, particularly about the neck, the sclerotia may form in a solid crust. Onions that do or do not have superficial sclerotia often have part of their surface covered with the characteristic ashen-gray fruit-layer of the parasite. The roots may be included also in the decayed area, especially if the bulb is attacked at its base. Occasionally soft-rot bacteria follow the neck-rot, causing the onion to become soft, watery, and foul smelling. The neck-rot, when unaccompanied, results in a dry-rot.

Infection takes place through wounds at the neck of the bulbs during or following harvest, the invaded area continuing to enlarge while the onions are curing and after they are housed. The fungus seldom passes from bulb to bulb in storage unless the adjoining tissue is exposed by open wounds.

The Botrytis survives the winter by means of the sclerotia and as mycelium in the decaying host. The spores are blown by wind or carried on tools and clothing to the flower head, the leaf sheaths, the inner dry scales, and at harvest time to the cut tops and roots.

Control

If the fact is kept in mind that well-dried, well-stored onions are seldom affected, protection will seem fairly simple. First, the onions should be so grown that they will mature readily. Late applications of fertilizers and the presence of downy-mildew, weeds, and wind barriers should be avoided. At harvest the tops should be cut very close and every attempt made to dry the stubs before placing the crop in storage. It has been shown that mature bulbs or sets may be dried artificially to good advantage. They are placed in shallow trays and held at 90° to 120° F. for from forty-eight to seventy-two hours. In addition, all thick-necked bulbs, or scallions, are removed, as their slow drying qualities cause them to succumb quickly to the disease.

The onions should be stored in slatted crates, which are so piled that air can circulate all about them. The temperature should be kept as nearly 32° F. as possible, and the humidity of the air as low as the arrangement of the room will permit. A steeply pitched roof with ventilators at the peak will aid in removing the warm moist air. If the doors are then kept tightly closed on damp misty days and opened only when the air is cool and dry, the amount of shrinkage from rot in an onion crop can be much reduced.

TOMATO

Among the control measures for the insects and diseases that affect tomatoes are the selection of resistant varieties, seed treatment, and spraying or dusting in the seedbed and in the field.

POTATO FLEA BEETLE

(*Epitrix cucumeris* Harris)

The small black potato flea beetle often attacks tomato plants in the seedbed and when they are first set out in the field. These beetles are only from 1/16 to 1/12 inch in length. When disturbed, they jump quickly into the air and disappear from view. They are commonly known as "fleas." The beetles feed on both the upper and under surfaces of the leaves, eating out small round holes in the leaf tissue but usually leaving the epidermis on the opposite side intact. This soon dies and breaks away, leaving the foliage riddled with small holes. Badly injured leaves turn yellow or brown, curl up, and die.

Control

The two or three early applications of bordeaux mixture of the same strength as that used for the control of leaf-spots (page 74) are of great value in protecting tomato plants from flea-beetle injury.

WIREWORMS

When tomatoes are planted on land badly infested with wireworms, there is danger of severe injury. The wireworms bore up through the stems causing the plants to wilt and die.

Control

Much may be done to prevent wireworm injury by planting the tomatoes, in fields relatively free from these worms. Fields that have been in hoed crops or in clear stands of buckwheat, clover, or alfalfa are usually not heavily infested. Grass sod on the other hand is likely to harbor an abundance of wireworms and should be avoided in a rotation in which tomatoes are to be grown.

BACTERIAL CANKER

(Caused by *Aplanobacter michiganense*)

Bacterial canker only of late years has caused any particular damage in the State. The first symptoms of the trouble are wilting, rolling, and browning of the leaves on one side of the plant. This is followed by pale yellow streaks up the stem, which later may crack open. The pith may disappear or become discolored. In severe cases the whole plant dies.

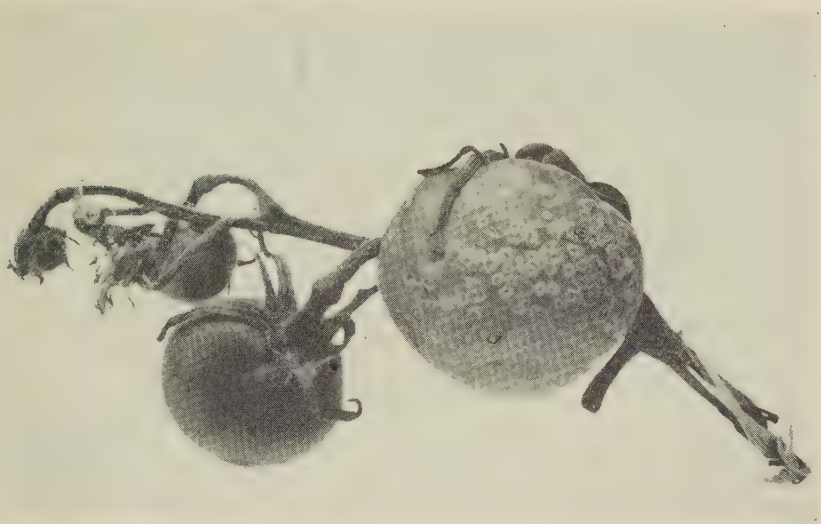

Figure 10. Bacterial-canker spots on tomato fruit

The bacterial canker disease is caused by a bacterium, and may become complicated by the presence of other bacterial organisms in the diseased tissue. The causal organism inhabits, primarily, the food-conducting tissue of the plant; later, collapsing this tissue, it may extend into the pith or through cracks of the stem to the outside of the plant. It winters over on the seed and in the old diseased plant refuse, and in the South is known to remain alive in the soil for more than a year.

Control

Little work has been done on control measures. Preliminary tests have shown that the disease may be carried with seed harvested from diseased plants. In an attempt to control or eliminate this disease, the following precautions, which are considered good practices in tomato culture, should be observed: Care should be taken to select seed from healthy plants only. Plowing and complete destruction of tomato refuse should be practiced, as the organism may live over the winter in tomato refuse. It is advisable to rotate crops so that tomatoes are grown on the same area only once in three or four years, Seed should be treated with corrosive sublimate, 1–3000 (1 tablet in 3 pints of water or 1 ounce in 22 gallons of water), for five minutes, rinsed in clean water, and dried, or planted before thoroughly dry. The disinfecting solution should be kept in wooden, glass, or glazed crockery containers, and used only once. The seed may be tied loosely in cheesecloth bags, submerged in the solution, and agitated frequently to remove air from the bags and the seed.

EARLY BLIGHT AND LATE BLIGHT

(Caused by *Macrosporium solani* and *Septoria lycopersici*)

Early blight and late blight may cause much damage on the foliage of tomatoes, and the early blight may cause much rotting of the fruit. The early, or Macrosporium, blight is the same as that found on the potato and is the cause of the leaf-spot so prevalent in New York State. The late, or Septoria, blight is rarely found causing much damage so far north as New York. The early blight is characterized by brown spots with concentric rings on the leaves and black rot spots on the fruit, and the late blight by small whitish spots with minute black fungous fruit bodies on the leaf. Both cause defoliation of the plants, and for this reason may result in sunscald of the fruit later.

Both fungi are carried in the old diseased plant refuse and will remain alive in the soil at least as long as the tomato stems are not completely rotted. The early blight is carried also on or in the seed. Related weed hosts may keep the two fungi alive for a long time in any given field.

Both parasites grow best in wet weather, and are aided in their dissemination by the splashing of rain. Both require a fairly high temperature for abundant infection. The spores of the Macrosporium will germinate best at about 80° F., while the Septoria has a range of 60° to 80° F., with the optimum at about 75° F. Therefore, in a uniformly cool season the diseases do not spread so rapidly.

Control

Aside from more detailed control measures, the following general recommendations are offered: Plowing under deeply all diseased refuse directly after harvest, three-year or longer rotations with crops not belonging to the tomato family, destruction of all weeds related to the tomato family growing in the field or within 50 feet of the field; great caution in guarding against the possibility of getting diseased refuse in the seedbed, and the procuring of seed from perfectly healthy fruit.

The most important measure, however, is the spraying or dusting in the seedbed and for two or three weeks after the plants are set into the field. Bordeaux mixture, 4–4–50, or copper-lime dust, 20–20–60, is the generally accepted fungicide. In the seedbed, the spray may be put on with a hand sprayer, provided the pressure is kept as high as possible and the nozzle has a fine-holed disc. In the field, the spraying should be done with a traction or engine-driven sprayer, and the nozzles so arranged that every part of the plant is covered. A hand duster is very handy for the seedbed and can be used even in the field if the acreage is small. The applications of either spray or dust should be made at weekly intervals,

beginning in the seedbed as soon as the plant has true leaves, and continuing until three or four applications have been made in the field. Late applications of a fungicide are discouraged because they tend to delay ripening, and therefore the fruit may come on a late market when the price is low, or the crop may be much injured by frost. Early tomatoes probably do not need spraying or dusting in the field. The seedbed applications, however, should not be neglected.

Some varieties are much more resistant to leaf-spot than are others. The Ponderosa, the John Baer, and the Earliana are rather susceptible, the Stone and the Norton are fairly resistant, and the Marglobe is almost immune.

Since the late-blight fungus is rarely found in this State, its control during hot seasons can be procured by planting New-York-State-grown seed, which usually is free from infection.

TOMATO WORM

(*Phlegethontius quinquemaculata* Haworth)

Tomato foliage is sometimes attacked by large green or brown caterpillars which, when full-grown, are 3 or 4 inches in length. Owing to their large size and their voracious appetite, these caterpillars are able to consume a great quantity of leaves and may defoliate the plant. Fortunately they rarely become excessively abundant in New York, and applications of insecticides for this pest are unnecessary. Whenever the caterpillars are discovered, they should be thrown on the ground and crushed underfoot. (See cover illustration.)

LEAF-MOLD

(Caused by *Cladosporium fulvum*)

Few greenhouse tomatoes escape entirely the presence of the leaf-mold fungus, but field-grown tomatoes in New York State are seldom affected. The disease begins as light yellow spots on the upper side of the leaf. On the corresponding lower side greenish or purple mold soon appears. Finally the leaf tissue dies and the leaf curls up and drops. The mold is seldom found on the stem, and is difficult to detect on the fruit.

The disease is caused by a fungus that lives over in the seed and in the old diseased plant parts that are not destroyed at the end of the season. The parasite is splashed from plant to plant during the watering, and may also be carried by insects. The mold is very sensitive to dryness and this in turn is determined largely by the light and the temperature in the greenhouse. The fungus grows best at 65° to 70° F. when the soil or the air contains much water. Consequently the disease is present in greatest abundance where the greenhouse is not well ventilated.

Control

Since the leaf-mold must depend for growth on almost a completely saturated air, the principal control measure is the proper manipulation of the greenhouse to keep the humidity too low for growth of the fungus. Some of the steps in obtaining this condition are: wetting the plants as little as possible when watering, keeping the ventilators open even if extra coal is required for heating the house, letting in all the sunshine available, and planting the vines far enough apart so that air can circulate among them.

In some houses it has been found profitable to install fans of various types to move the otherwise stagnant air. The dry, warm air is drawn into the house and the water-laden air is expelled. This movement takes care of the immense amount of water given off by large tomato plants, for air moving at only one-half mile an hour has twice the evaporating possibilities of still air. In addition, it eliminates air pockets which are present even though the ventilators are wide open.

If no fans are available, fairly satisfactory results can be obtained by having continuous ventilator openings both at the top of the house and along both sides near the ground. If the plants are set in rows crosswise of the house so the air currents can follow down the row, the exchange of air will progress rapidly. This can be facilitated also by planting two rows closer together and the next two rows farther apart. This will permit the usual number of plants in a given space and at the same time will give the air currents wider lanes through which to move unobstructedly.

If the mold is present in cold weather, lowering the night temperature of the house to 55° F. for several nights in succession will check the growth of the parasite. This lowering of the temperature should be practiced as much as good growth of the plants will permit.

In poorly lighted and ventilated greenhouses, spraying with bordeaux mixture, 4–4–50, may be justified. It is necessary to have a power machine with high pressure in order to do effective work. The sprayer can be stationed on the outside of the house and the spray directed from a long hose. The nozzles must be equipped with fine-holed discs, and all parts of the plant sprayed at least once a week.

Some growers heat sulfur in porcelain dishes on electric stoves placed at regular intervals throughout the house. The sulfur must not get hot enough to burn, for injury to the plants will then result. This sulfur fumigation should be continued for a two-hour period just before the house is closed for the night, and repeated at weekly intervals as long as there is danger of loss from the disease.

Resistant varieties are being bred, and finally may become available to growers whose crops have suffered damage from the mold.

MOSAIC

(Caused by a virus)

The tomato mosaic is a very serious trouble in most of the older tomato-growing districts where control measures have not been followed closely. The virus causing the disease is the same as the one on tobacco and other closely related plants, not only among the cultivated crops but also among some of the very common weeds.

In the common tomato mosaic the leaves are mottled with yellow and green and their surfaces are warty. The yellow areas may die and turn brown. The affected plants are dwarfed and usually bear little fruit, although the amount of blossoming may be normal. Occasionally the fruit is affected with russeting, with streaking, or with raised blotches. Plants badly affected in the seedbed may die when set into the field. Later infection never causes death.

The cucumber mosaic on tomato allows very little of the leaf to develop except along the midrib. Therefore this disease is known as *shoe-string* or *filiform leaf*. The leaves near the top of the plant are most conspicuously affected.

The mosaic virus is carried by aphids and other sucking insects, and will live in the soil for two months or possibly longer. The common tomato mosaic virus lives overwinter in the roots of such hosts as ground cherries (husk tomatoes), horse-nettles, jimson weed, night-shade, bitter-sweet, matrimony vine, and other related plants. The cucumber mosaic virus lives in the roots of the additional hosts mentioned on page 59. Investigators at various times have tried to show that the virus is carried in the tomato seed, but in America this supposition has been rather definitely disproved.

Control

The most important control measure is the eradication of the weed hosts near or in the tomato field, and especially those near the seedbed. If young plants are kept healthy, a fairly large plant may develop before the influence of the disease can reduce the yield much. In the greenhouse it is important also to avoid all tomato refuse in the seedbed, and to remove any mature, living tomato plants in the same greenhouse where young plants are being grown. Since the virus can live in the soil, the seedbed or a new crop in the greenhouse should not be planted for at least four months after the old crop has been removed.

The virus can live for a long while in natural leaf chewing tobacco, and frequently is spread to tomato seedlings when the workmen expectorate over the bed.

In greenhouses the mosaic virus is disseminated when the plants are pruned. It has been shown that the later infection is much less common

if the workmen occasionally wash their hands with soap and frequently dip their pruning knives into formaldehyde (1 part in 20 parts of water). Breaking out the undesirable shoots in pruning permits less chance of contamination than does cutting.

Seed treatment and spraying have not proved effective in controlling mosaic.

STREAK

(Caused by a combination of two distinct viri)

Streak is merely another form of mosaic. It has been a common disease in greenhouses for many years and sometimes causes much loss.

The trouble seldom is noticeable until the plants are fairly well grown. It infects leaves, stems, and fruit. The most prominent symptoms are the dark streaks on the stem, the spotting and sudden blighting of the upper leaves, and the dwarfing of the plant. Dead areas form in the leaves, especially along the veins, and brown streaks appear on the petioles. Light brown, sunken spots, variable in size, may be found also on the fruit. In severe cases the whole plant dies.

One kind of streak can be produced by inoculating the tomato plant with both the tomato mosaic virus and the potato virus. When the two diseases are together, they seem to be more virulent and kill at least parts of the plants. A second type is produced by a combination of tomato and cucumber mosaics on the same plant. In fact, any other host mosaic that is able to pass over to the tomato seems to cause the disease known as *streak* when it becomes mingled in the plant sap with the ordinary tomato mosaic.

Control

The control measures for streak are the same as those given for mosaic (page 77). Here again should be emphasized the destruction of weed hosts and the practice of not following tomatoes immediately after tomatoes in the greenhouse. It has been suggested that an excessive use of nitrogen in the fertilizer increases the susceptibility of the tomato plant to the disease. Therefore if streak is expected to be present, the nitrogen application should be reduced and the superphosphate and potash increased. Even when streak has begun to appear, a side dressing of these two elements sometimes helps. It seems to be of value only in certain types of streak and not in others.

POTATO LATE BLIGHT

(Caused by *Phytophthora infestans*)

During a year when potatoes are blighting severely and tomatoes are grown in close proximity, the green tomato fruit may become infected. Rather greasy looking spots occur on the green surface. The lesions may

be small or cover nearly the entire surface of the fruit. They are not sunken, and the flesh remains firm until secondary rot-producing organisms follow the Phytophthora. When the fruit is cut open, the tissue to varying depths is brown in color. The foliage is not attacked.

Control

Apparently the disease never affects the tomatoes in this State unless diseased potatoes are near. Therefore the one completely successful control measure is to separate the tomato and potato fields by a distance of 10 rods or more. If the two have to be planted together, weekly spraying with bordeaux mixture, 4–4–50, will control the growth of the fungus.

BLOSSOM-END-ROT

(Caused by undesirable environmental conditions)

The first symptom of blossom-end-rot is a slight water-soaked area about the blossom-end. The lesion soon darkens and enlarges in a constantly widening circle until the fruit begins to ripen. The decaying spot may be merely a speck or it may involve half or even more of the tomato. Sudden lack of water is the principal cause of the trouble.

Control

Inasmuch as blossom-end-rot is so closely related with the water supply, the one important step in controlling the disease is governing the moisture supply in the soil. The land should be well drained, and plenty of humus should be available to retain the moisture during a dry period. If drought occurs, the cultivating should be very shallow, so that only enough soil is stirred to fill any cracks that may appear and to kill the weeds. Surface scraping even may be preferable. In wet weather, the soil should be stirred enough to cause the evaporation of excess water.

In the hotbeds or the greenhouse young plants should not be grown too quickly nor unusually slowly. The plants also should not be subjected to too sudden and severe hardening before planting. A steady growth, both as a seedling and as a plant in the field, will eliminate much of the trouble. The varieties of tomatoes that are most resistant to leaf-blight usually suffer most from the blossom-end-rot. A defoliated plant usually does not have the disease. It, however, has not proved profitable to remove the foliage in order to protect the fruit from blossom-end-rot.

CARROT

The commercial production of carrots in many localities in western New York has been seriously threatened by the losses occasioned by the carrot rust-fly. On Long Island much loss has been caused by carrot weevil and some by leaf blights.

CARROT RUST-FLY

(*Psila rosae* Fabricius)

The most serious insect enemy of carrots in New York is the larva, or maggot, of a small shining dark-green fly with yellowish head and red eyes. The larva is a slender, straw-colored maggot about 3/10 inch in length. It burrows through the roots in all directions, leaving channels that soon acquire a rusty color. Carrots, parsnip, and celery are subject to attack. The insect breeds also in wild carrots.

The rust-fly passes the winter in the puparium stage in the soil. There are two main broods of flies and a partial third brood each season. The first appears about May 20, the second the last week of July, and the third the last week of September. The flies deposit their eggs in crevices in the ground close around the base of the plants. The eggs hatch in about a week. The young maggots work their way down along the main root, but feed for some time on the smaller roots and usually attain considerable size before attacking the main root itself. This habit is of great importance because it makes it possible to leave late carrots in the ground for some time after the larvae of the second brood have hatched without their becoming infested.

The common practice of growing early and late carrots in the same general locality is favorable to a rapid multiplication of the rust-fly and results in a maximum injury to the late crop. The early crop supplies an abundant source of food for the larvae of the first brood, and great numbers of second-brood flies are produced to infest the late crop.

Control

In localities where late carrots are grown extensively, it would pay to eliminate all early plantings of carrots, celery, or parsnips, and to plant the main crop after the first of June. When this plan is followed, the first brood is largely eliminated for want of food plants in which to breed, with a corresponding reduction in the number of flies appearing in the second brood. Where it is not feasible to discontinue the growing of early carrots, parsnips, and celery in the locality, the alternative is to plant the main crop after June 1, when the danger of infestation by the first brood has passed, and to harvest the crop early in September before the second brood becomes destructive. By following this method, the yield may be reduced somewhat, but it enables the grower to produce clean carrots profitably even in districts where the rust-fly is normally destructive When it is desired to hold the late crop of carrots in the ground as long as possible, the field should be carefully examined at least twice a week,

beginning about September 1. By carefully scrapping with a knife blade several carrots pulled from different parts of the field, even a slight infestation can be detected. When the first larvae are found in the carrots, harvest should commence at once.

In cases where it seems necessary to plant carrots later than the first week of June, the crop may not be ready to harvest early enough in September to avoid injury from second-brood larvae. In such cases it is important to choose a field as far removed as possible from early carrots and early celery and from celery seedbeds of the current year.

For the home garden, the crop may be grown under a tightly constructed cheesecloth screen, using a fabric of from 24 to 30 threads to the inch. Perhaps a more satisfactory method for general use in the home garden is to treat the growing plants with a suspension of calomel. This material may be used at the rate of 3 or 4 ounces to 10 gallons of water. The suspension must be constantly agitated as it is applied to prevent settling. The suspension should be used at the rate of 1 gallon to from 30 to 40 feet of row. Two or three successive applications for each brood, starting when the flies first begin to appear and repeating in a week or ten days, should give a satisfactory control of the rust-fly on carrots.

Recent experiments at the New York State Agricultural Experiment Station at Geneva indicate that good control of the rust-fly on carrots can be obtained by broadcasting crude napthalene over the fields. In these experiments six treatments were made, using 400 pounds of the napthalene per acre for each application. In protecting the main crop of carrots from the rust fly, the seeding should be deferred until about June 1, to avoid injury by the first brood. The first treatment of napthalene should be made late in July when the flies of the second generation commence to appear, and the other should be made at intervals of about a week until the peak of emergence is well passed. Ordinarily six carefully timed applications have given excellent control and have extended the growing season from one to two months.

CARROT WEEVIL

(*Listronotus latiusculus* Boheman)

On Long Island early crops of carrots are subject to attack by the larvae of a small dark brownish weevil which in some cases ruins as much as 75 per cent of the crop. The insect injuries also curled-leaved parsley, hymicha, and dill. Its principal wild food plant in this area is wild carrot. Most of the damage is done by the larvae. Badly injured carrots are almost unsalable. The injury to the parsley roots induces a yellowish

sickly condition of the leaves, greatly reducing their market value. With hymicha the injury to the roots may be severe enough to render them unsalable.

The carrot weevil hibernates in the adult stage in the immediate vicinity of the infested fields. The beetles appear in May and soon begin to deposit eggs. The female first hollows out a cavity in a leafstalk in which she deposits 3 or 4 eggs, sealing up the opening with a blackish substance. The eggs hatch in about ten days, and the young grub begins feeding on the inside of the stalk. It usually burrows downward and often enters the root without coming to the surface, but some of the grubs, hatching in cavities at some distance from the base, leave the stem and either fall or crawl to the ground where they soon find their way into the carrot itself. Usually several larvae attack a single carrot. Feeding is usually confined to the upper and the outer part of the root. The burrows take a zig-zag course and often coalesce, producing large areas in which most of the surface tissue of the carrot has been destroyed.

The larva becomes mature in about two weeks, leaves the root, and transforms to a pupa in an earthen cell within an inch or so of the carrot in which it developed. From six to twelve days are spent in the pupal stage. The beetles of the second brood appear in July, and lay eggs for a second brood of larvae which injure the carrots during August. A partial third brood may develop but causes little injury to late carrots and is unimportant.

Control

Although the weevils are provided with wings, they seem to use them very little, and the migration from field to field takes place very slowly. For this reason carrots can be grown free from injury even in badly infested localities by selecting for carrots fields not recently used for this crop or for curled-leaved parsley, hymicha, or dill. Careful attention to the proper rotation of crops seems to give an entirely satisfactory solution of the carrot-weevil problem.

LEAF BLIGHTS

(Caused by *Macrosporium* and *Cercospora*)

The carrot leaf blights affect the leaves and the petioles, which turn yellow and then change to brown. During severe infection, the whole top of the plant may be killed.

Control

Spraying with bordeaux mixture, 4–4–50, or dusting with copper-lime dust, 20–80, at weekly intervals, beginning when the plants are about 3 inches tall, will control the disease. Horse-drawn machines cannot be used; therefore it is necessary to use hand machines or small tractors.

STORAGE ROTS

(Caused by various fungi and bacteria)

A number of rots may affect the carrot roots under poor conditions of storage. In most cases these rots spread rapidly in the bin if the roots are piled closely together. The temperature of the storage room should be kept as near 32° F. as possible and there should not be too much humidity in the air. The room should be free from dripping water. Instead of solid piles of roots, there should be a layer of roots, then a layer of straw, old leaves, or other filler material. Only healthy, unblemished carrots should be put in storage, and every precaution practiced not to break the skins of the roots in piling them away for the winter.

CELERY

In some muck areas the carrot rust-fly has injured celery seriously. The leaf blights are prevalent during any year when the rainfall is more than average. Spraying or dusting in the seedbed and field and care in the rotation with carrots to avoid the fly are important control measures.

BLIGHTS

Late blight (*Septoria apii*)

Early blight (*Cercospora apii*)

Bacterial blight (*Bacterium apii*)

Three separate and distinct blights, all controlled by the same means, attack celery and are characterized as follows: (1) Early, or Cercospora, blight produces dead, ashen-gray velvety areas; (2) late, or Septoria, blight causes brown spots on the leaves and the stems, in which are the tiny, black, fruiting bodies of the fungus; and (3) bacterial blight produces spots that are more reddish brown than those of late blight, have a yellow halo about the lesion, and do not contain black fruiting bodies. Characteristic symptoms may appear on both the leaf blade and the petiole, or stalk, of the plant at any stage of its development. Plants in the seedbed as well as in the field are subject to attack.

The effect of the celery blights is to lessen the attractiveness of the produce and thus decrease its market value. When present to any extent, they also retard growth, materially reduce the yield, and lessen the keeping quality of the product. All of them live over from year to year in the diseased portions of the plants which remain in the field after the marketable produce has been removed, and late blight may be carried with the seed. Early in the season the incubation period of the casual organism is probably from a week to ten days, while later in the season it may be much longer. Infection of the leaves and the spread of the disease is favored by rain and by moisture on the plant.

Control

Soil for the seedbed should be selected from that which has not grown celery for more than three years, and which is free from celery refuse. This selection of the bed should be accompanied by thorough spraying with bordeaux mixture, 5–5–50, or dusting with copper-lime dust. Weekly applications are made in the seedbed; the applications at this time being very important. This is followed by spraying or dusting in the field.

It is recommended that spraying be started as soon as the plants become established in the field and continued throughout the season at intervals of a week to ten days. The spray or the dust should be applied to the plants just before cultivation, for, if any old diseased refuse is in the soil, the cultivator will drag it to the surface of the soil, where it will fruit and cause infection if the foliage is not protected. If the disease does not appear three weeks prior to harvest time, continued spraying probably is not essential.

Even though spraying is done, as long rotations as possible should be practiced, and the diseased refuse left in the field should be plowed under deeply or burned.

Seed treatment has not proved beneficial under New York conditions.

TARNISHED PLANT-BUG

(*Lygus pratensis* Linnaeus)

Celery is subject to serious injury caused by the punctures of an inconspicuous brownish bug, mottled with various shades of reddish and yellowish brown, and about 1/5 inch in length. This tarnished plant-bug is shy and very active, taking flight at the slightest alarm. It feeds on a great variety of wild and cultivated plants, being especially abundant on certain weeds, such as wild carrot and ragweed.

The tarnished plant-bug hibernates in the adult condition under trash and dead leaves in woodlots and in stone piles, stone walls, and other convenient shelter. The bugs emerge very early in the spring and feed on the opening buds of many kinds of trees and shrubs. The female inserts her eggs in the green tissue of her food plants. The eggs hatch in about ten days. The nymphs are green, marked on the thorax with four black spots. In the older nymphs the thorax and the wing-pads are mottled with brown. There are five nymphal stages, the insect becoming mature and acquiring wings at the fifth molt. The life cycle requires from twenty-five to thirty days. There are probably four generations annually.

Injury to late celery is largely caused by the feeding of the adult bugs. These adults migrate into celery fields from weedy fields and waste land, where they have bred in great numbers. They attack the celery plants that are blanching and puncture the tender stalks, producing

large brown wilted spots and a darkening of the tissue at the joint. This injury is known among celery growers as *black-joint*. Celery injured in this way does not keep so well in storage and its market value is greatly lessened. In the early crop the attack is of a somewhat different nature. In some seasons the bugs deposit their eggs in the early celery and the nymphs hatching from these eggs severely injure the hearts of the plants.

Control

Recent experiments indicate that the injury can be lessened to a considerable extent by spraying or dusting with hydrated lime. In spraying, 1 pound of lime is used in each gallon of water, and from 175 to 200 gallons are applied to the acre. If the lime is used as a dust, about 75 pounds are required to the acre. The lime should be applied at intervals of ten days to two weeks, beginning when the plants are 6 to 8 inches high. For early celery it may be necessary to begin the application earlier to prevent the bugs from depositing eggs.

CARROT RUST-FLY

(*See* page 80)

The carrot rust-fly may attack celery both in the seedbed and in the field if the plants are available during the egg-laying period. Celery seedbeds may be protected by screening with cheesecloth during the period when the flies are active, from about May 25 to June 10 in western New York. Protection is needed for seedbeds in which the plants are to remain after about June 20; where the plants are to be set out before that date, screening is unnecessary.

To avoid injury to the celery crop in the field, it would aid materially if late celery could be grown at some distance from early celery or early carrots. The growing of early crops of carrots and celery tends to produce an immense number of carrot rust-flies to infest late crops of these vegetables grown near-by.

Serious injury to late celery may be greatly reduced by deferring transplanting till the last week of June, and thus avoid the eggs laid by the first brood of flies.

PINK-ROT AND BACTERIAL SOFT-ROT

(Caused by *Sclerotinia sclerotiorum* and *Bacillus* spp.)

In trenches and sometimes in storage houses, a colorless soft rot, pink-rot, or bacterial soft-rot, may ruin a large part of the stored celery. In mild cases only the outer stalks or the base of the plant are affected.

Under favorable conditions, the whole plant may become soft and worthless. Both organisms require air saturated with water to grow well. The bacteria need a fairly high temperature, while the Sclerotinia will continue to grow until the temperature has reached the freezing point. Trenches should be ventilated as well as possible, and filled only after the cool weather has come. Storage houses that have refrigeration should be kept at a temperature of about 31° F.

ASPARAGUS

The Washington varieties of asparagus have solved the rust problem. If, in addition to choosing these varieties, the control measures are followed for the eradication of the beetle, nearly all troubles of the asparagus crop are eliminated.

RUST

(Caused by *Puccinia asparagi*)

At present there are no serious diseases of asparagus. Rust may be present occasionally. The bushy tops of the plants become covered with reddish or black pustules. This prevents the normal manufacture of food and its storage in the roots, thus decreasing the succeeding season's yield. The rust lives overwinter mostly in the form of teliospores that can cause infection on the young shoots in the spring. The rust fungus thrives best where there are few dashing rains but where dew or fog is prevalent. Dry soils are favorable for its development.

Control

It is advisable to burn the diseased tops late in the fall. During the cutting season, all plants should be kept cut. Only resistant varieties should be planted. Among these, Palmetto and Argenteuil are fairly safe. The most resistant ones, however, are Mary Washington and Martha Washington, which are being used so generally that rust is now only rarely found in New York.

ASPARAGUS BEETLES

(*Crioceris asparagi* Linnaeus and *C. duodecimpunctata* Linnaeus)

Two closely related beetles attack asparagus in New York. Both species are about the same size, being about ¼ inch in length. The head, the underparts, the legs, and the antennae of the common asparagus beetle are bluish black in color; the markings on the wing covers vary greatly. The inner margin of each wing cover is bluish black, the outer margin and

the tip are orange, and the intervening space is yellowish white, broken into three spots by bluish crossbands. The twelve-spotted species is reddish orange in color; the wing covers are marked with twelve distinct black spots. The dark gray slug-like larvae of the common asparagus beetle feed openly on the leaves; the larvae of the twelve-spotted species feed inside the berries. The adults of both species emerge from winter quarters at the time the young asparagus shoots are just coming up. They attack the tender tips, eating out holes and producing a brownish discoloration of the tissue. The adults of both species and the larvae of the common species attack also the leaves, often nearly defoliating the plants and seriously interfering with their growth. The beetles also eat out irregular areas in the bark or rind of the stems, giving them a spotted appearance.

Control

In asparagus fields in which the crop is being cut for market, the injury to the young shoots by the larvae may be prevented by cutting the crop clean every three to five days. In this way all the eggs deposited on the shoots will be removed before or very soon after hatching. All volunteer plants should be destroyed, but it will often pay to leave a row here and there uncut to serve as a trap on which the beetles will congregate, feed, and lay their eggs. Here they may be poisoned by an application of calcium or lead arsenate. After the cutting season is over, the plant may be protected from beetle injury by two or three applications of calcium or lead-arsenate dust, 15 pounds mixed with 85 pounds of hydrated lime.

The use of poultry for the destruction of the beetles is practiced with good results in some localities. The asparagus field is surrounded with a chicken-wire fence, and poultry are allowed the run of the field. Thirty or forty hens are sufficient to keep a two-acre field practically free from the beetles during the early part of the season. When the plants have grown to a considerable height, some of the beetles will be out of reach of the hens, and the beetles may be abundant in the fall. It is rarely necessary, however, to resort to spraying in fields in which poultry are allowed to run.

SWEET CORN

The insects and diseases of corn in New York State are generally not of a serious enough nature to require control measures. An occasional field may have much smut or corn ear-worm, and in some sections the corn-borer is a menace. Crop sanitation is then the best recommendation.

SMUT

(Caused by *Ustilago zeae*)

The smut of corn probably was present when the white man first came to America. It is now present in nearly all countries where corn is grown, being of great economic importance in North America.

Sweet corn is more susceptible than is field corn, and under very favorable conditions may become infected during the seedling stage.

The corn plant may be infected at any time in the early stages of its development, but gradually grows less susceptible after the formation of the ear. Any part of the plant aboveground may be invaded, although it is more common to see smut boils on the ears, the tassels, and the nodes than on the leaves, the inter-nodes, and the aerial roots. The boil is composed of a white smooth covering enclosing a great mass, sometimes 4 or 5 inches in diameter, of black greasy or powdery spores. After the maturity of the spores, the covering becomes dry and brittle, breaks open, and permits the black powdery contents to escape. The smut spores are blown long distances by the wind and are particularly prevalent if there is much dust in the air. They will germinate in ordinary rain water but germinate very much more prolifically in the drainings from barnyard manure. Consequently, it is scattered over the farm with manure and has been known to pass through the digestive tract of animals without losing its germinating ability. The germ tube of the germinating spore ordinarily does not enter the plant directly, but a few drops of dew caught in the leaf sheath will remain long enough for the fungus to start a luxuriant growth, and it is only when it is growing in this manner that it can enter the plant.

Hot dry seasons are favorable for the growth of the smut fungus, although drought is only indirectly responsible for the smut increase. When the soil is dry, the dust can blow more readily, and it is by means of air-floating dust that the fungus spores are carried from one farm to the other. Furthermore, when there is a drought, the temperature usually is high, which is especially favorable for the germination of the spores.

Control

It is to be remembered that the seed dealer or the seed grower is not to be blamed for the smut that the gardener may have on his crop, for the smut is not transmitted with the seed. Therefore, seed treatment is never of any value.

There is only one control measure, and that one is rather unsatisfactory. If every grower in a given community will go through his field two or three times during the season and cut out all of the smut balls before they have time to break open, and remove them in some receptacle that

will not permit the spilling of the spores, the smut can be reduced. The material that is cut out should be buried deeply or placed on a hot enough fire to be destroyed. One year of cutting is not sufficient to cause much difference in the amount of the disease, but, if this cutting is continued for two or more years, the smut will gradually be eliminated. This is true, however, only if adjoining neighbors cooperate in following the same recommendation. The removal of the smut should in each case be accompanied by rather long crop rotations.

CORN EAR-WORM

(*Heliothis obsoleta* Fabricius)

The corn ear-worm is a native insect much more abundant and destructive in the South than in New York. It is often confused with the European corn-borer. The amount of damage caused by the ear-worm varies greatly from year to year, depending largely on the locality and the length of the growing season. It is always more injurious on Long Island than in the rest of the State, the loss to late sweet corn sometimes amounting to one half or more of the crop. In the rest of the State the insect causes little or no damage during many years, but occasionally the late crop may be seriously injured. Injury is likely to occur up-state only in years when the growing season is long and warm.

Under New York conditions the corn ear-worm hibernates in the pupal stage in the ground. The moths emerge in the early spring over a rather long period, a month or more. The moth has a wing spread of about one and one-half inches. The front wings are straw-colored, usually marked with a dark spot in the middle; the hind wings are creamy white, with a blackish border and a dark spot near the middle. The moth deposits her eggs on the leaves, the tassels, and the silk of corn, the silk being preferred above all others for oviposition. During the early part of the season before corn is available, the insect breeds on other plants, including several common weeds. Under New York conditions, the principal injury is caused by the larvae feeding inside the husk on the kernels of corn. The young larvae quickly work their way down through the green silk and in a few minutes reach the top of the ear. They then begin to feed on the silk and the unripe kernels under the husk. The injured kernels and the excrement left by the larvae in its burrow serve as a medium for the growth of molds and bacteria which greatly augment the injury inflicted by the insect.

Control

No practical method of controlling the corn ear-worm on corn has been discovered. When sweet corn is grown for the cannery, early planting

is advisable; but, as this practice tends to increase the injury from the European corn-borer, it can be followed only where that insect is not likely to cause significant injury. Early planting is, of course, out of the question where corn is grown in succession for the market. Much benefit may be derived from fall or winter plowing land on which an infested crop has been grown, in order to destroy the pupae. As large an area as possible should be included in this treatment as the moths are capable of flying a considerable distance.

EUROPEAN CORN-BORER

(*Pyrausta nubilalis* Hübner)

Since 1917, when the European corn-borer was discovered in Eastern Massachusetts, it has been spreading rapidly from a center in New England and another on the shores of Lake Erie. It is now found in New York wherever corn is grown. Fortunately it has not proved to be so serious a pest of field corn as was feared, but in certain areas, notably along Lake Erie, it has become an important consideration in the growing of sweet corn.

When full-grown, the corn-borer larva is nearly 1 inch in length, is dirty white in color, has a brownish head, and is marked with transverse rows of small dark spots on the segments of the body. The borers may be found in all parts of the plant aboveground, where they burrow through the pith of the stalk, the stem that supports the ear, and the tassel stem. They enter also the midrib of the leaves, and are often found in the ears, feeding upon the silk, the husk, the unripe kernels, and burrowing in the cob. When abundant, they so weaken the stalk that the plant breaks over. Their presence on the ears of sweet corn makes the ears undesirable for use as green corn and greatly increases the cost of canning because of the expense of sorting out the infested ears.

The corn-borer passes the winter in the larval stage in its food plant unless it is disturbed, in which case it may migrate to some more suitable shelter. The borers are therefore often found in stems of rank weeds growing near-by the cornfield, in piles of leaves, in the crevices of fences, and in similar situations. In the spring the larvae transform within their burrows to brownish pupae, and about ten days to two weeks later the moths emerge. The moths have a wing spread of about 1 inch. The female moth is pale yellow in color, with darker irregular lines across the wings. The male moth is slightly smaller than the female and is much darker. When at rest, they fold their wings so as to appear triangular in shape. They are strong fliers, and with favorable winds may be carried for many miles. They are active mostly at night, but are rarely attracted to lights. The moths of the spring brood are to be

found in the fields for a period of from a month to six weeks during early summer. They deposit their eggs mostly on the underside of corn leaves in flat, compact clusters, each containing, on the average, from 15 to 20 eggs. The eggs are thin, flat, and scale-like, and are usually shingled one over the other in the cluster. Each female moth is capable of laying about 400 eggs. On hatching, the young corn-borers may feed for a short time on the surface of the leaves, but they soon find their way into the plant, often entering at the base of the leaves. They then burrow up or down the stalk, where they feed on the sweeter and more succulent tissues. They are often found at the base of the tassel stem, which is so weakened that it is easily broken over by the wind. These broken tassels are readily seen and serve to indicate the presence of the borer. The larvae become full-grown in about a month, having moulted, on the average, four or five times. In some cases six or seven moults may take place.

It is a curious fact that in New England the corn-borer has two generations a year, while in the rest of the country there is usually only one. The two-brood form is found in the eastern part of Suffolk County, while the single-brood variety occurs in other parts of New York. In the two-brood form most of the larvae pupate soon after reaching maturity and give rise to a second brood of moths in August and early September. These lay eggs and produce a brood of larvae which reach maturity in time to go into hibernation before the advent of cold weather.

In addition to corn, the corn-borer attacks a number of cultivated crops, such as rhubarb, beets, celery, and beans, but the infestation is not likely to be severe unless these crops are grown near infested cornfields. Under such conditions, millet, sorghum, and buckwheat may also be attacked, as well as a number of coarse-stemmed garden flowers, such as dahlias, chrysanthemums, gladioli, and the like. The corn-borer may also breed in a number of rank weeds, such as barnyard grass, cocklebur, smartweed, pigweed, and ragweed.

Control

The corn-borer has been found to be a very difficult insect to control. The larvae are not readily reached by insecticides, feeding as they do principally inside the plant; and the moths are but little attracted to lights, making it impossible to trap them. Recourse must be had to the destruction of the overwintering larvae. Except in areas of excessive infestation, most of the larvae are to be found during the winter in the corn plants or in large-stemmed weeds growing near-by. If the corn is cut close to the ground, and as early as the maturity of the crop will permit, few of the borers will be left in the stubble; if the stalks are utilized for ensilage in the usual way, most of the borers will be destroyed.

If the stalks are fed whole to cattle and the uneaten portions are tramped down in the barnyard, the greater proportion of the borers will be killed. To destroy all those that escape, all such material should be spread out in a field and plowed under early the next spring. It is better, however, to either chop or shred corn fodder that is to be fed in this way.

Cornfields should be plowed either in the fall or early in the spring, taking great care to cover all the stubble and the pieces of stalks that might harbor borers. If this is done, the borers will find themselves in unnatural conditions, and most of them will leave the buried stalks to seek a more suitable hiding place. If the surface of the field is clear of all litter, nearly all of the borers will fall prey to their natural enemies or succumb to exposure. In order to avoid bringing the stubble and the stalks to the surface when fitting the land, it is advisable to use a disc harrow for this purpose. All weeds, both on the field and up to 10 yards from the edge of the corn, should be plowed under or burned.

It has been found that corn is less seriously infested when planted rather late, after the principal flight of the moths is past, than when planted earlier. In some cases therefore late planting may result in less injury to the crop.

Since the moths can fly for considerable distances, the individual farmer cannot hope to succeed in controlling the corn-borer no matter how carefully nor persistently he practices these methods. To be effective, these practices must be employed by all the corn growers in a considerable area.

CUTWORM CONTROL

The means employed for the control of cutworms will vary according to the crop, the conditions under which it is grown, and on the habits of the species causing the injury.

In small vegetable gardens and greenhouses hand-picking may be practiced to advantage. Careful watch of the plants should be kept, and, whenever injury is noticed, the soil around the base of the plants should be searched and the cutworms destroyed. Shingles or small boards laid about the beds will form attractive hiding places for the worms during the day; here they may be easily found and destroyed. When such plants as tomatoes are transplanted, they may be protected by using cardboard or tin cylinders sunk a short distance in the soil. Tin cans with the top and the bottom removed are convenient for this purpose. Greenhouses often become infested by cutworms in the rotted sod used in the beds. This may be prevented by sterilizing the soil by steam before using.

Probably the most practical, cheap, and convenient method of cutworm control is the use of poisoned baits. These may be employed

equally as well in the home garden, the greehouse, or the field. A bait made according to the following formula has been found effective against the variegated cutworm and others of similar habits:

Bran		20 pounds
Paris green		1 pound
Molasses		2 quarts
Oranges or lemons		3 fruits
Water	(about)	3½ gallons

A cutworm bait made according to the following formula is somewhat cheaper and nearly, if not quite, as effective as that given above:

Bran		25 pounds
White arsenic		¾ pound
Water	(about)	3 gallons

The dry bran and paris green are thoroughly mixed in a tub or similar receptacle. The juice of the oranges or lemons is squeezed into the water; the remaining pulp and peel is chopped into fine bits and added to the water. The molasses is dissolved in the water and the bran and the poison are wet with it, the mixture being constantly stirred so as to dampen the mash thoroughly. Only enough water should be used to just moisten the mash; the mash should not be sloppy.

This quantity of bait will treat about 3 acres. The material should be scattered broadcast evenly over the infested area at nightfall. If applied during the day, it dries out and is not then attractive to the cutworms. In the garden or the greenhouse a small quantity of the bait may be placed near each plant.

DAMPING-OFF, BLACK-ROOT, OR WIRE-STEM IN THE SEEDBED

(Caused by various soil fungi)

There are in the soil a half dozen or more fungous parasites that cause damping-off. They usually grow very near the surface, and enter the plant at the point where the seedling emerges from the ground. All of them require for quick growth a high moisture content of the soil and the air.

Control

If the air and the surface of the soil are kept as dry as is consistent with good growth of the plant, damping-off can fairly well be held in check. In addition, the seed should be sown thinly enough in the bed so that later the plants will not be crowded. The beds in coldframes should be protected from fog or excessive rain. If the soil in the bed

is heavy and slow-drying, it can be improved by mixing with it a small amount of sand or by sprinkling sand over the surface. The watering should be done in the morning and preferably on bright days. Heavy applications of water at long intervals are more desirable than are frequent light sprinklings. Stirring the surface soil after an application of water helps it to dry and thereby reduces the chances of damping-off.

Correct conditions cannot always be maintained, particularly in hotbeds or in low greenhouses. Tight wooden rooms or metal boilers can be built, or bought, into which flats filled with dirt can be piled, and steam forced in until the soil is sterilized. If nematodes are not present, the soil may be drenched with formaldehyde, 1–50. Where steam or formaldehyde sterilization cannot be practiced, the application of another fungicide is desirable. It has been found that copper compounds, as copper carbonate and others, will quickly kill certain damping-off fungi. They, however, have little effect on Rhizoctonia. Corrosive sublimate, on the other hand, is very toxic to all the damping-off fungi that have been tested so far, including Rhizoctonia.

The copper carbonate, which will not dissolve, is mixed with 25 gallons of water, and poured over the newly seeded soil at the rate of 1 pint for each square foot of surface or it is poured along the row as the plants are coming through the ground. It may be applied later at the rate of 1 pint for each 5 feet of row. The applications are repeated as often as found necessary.

One ounce of corrosive sublimate (mercuric chloride) is dissolved in a little hot water and then diluted to 15 gallons. One pint of this solution may be applied to each square foot of soil at seeding time. There is more danger of seed injury with the use of corrosive sublimate than with copper carbonate; therefore a test should be made before large areas are treated to make sure that the conditions and the nature of the crop will permit the use of mercury compounds. When the seedlings are up, the applications are made in the same manner as that recommended for copper carbonate. Cabbage, cauliflower, and brussels-sprouts seedbeds are treated with the corrosive sublimate as suggested for the control of cabbage root-maggot (page 7).

There are various organic mercury compounds on the market that have been used successfully by some growers. These compounds should always be applied according to the directions on the container.

In a recent bulletin from the New York State Agricultural Experiment Station, Dr. Horsfall has shown that in many cases tomato damping-off can be controlled by treating the seed with copper. Any one of three treatments may be used. They are given here somewhat in the order of their preference.

One pound of blue vitriol is dissolved in 8 gallons of water, and the seeds, after being tied loosely in cheesecloth, are soaked in this solution for an hour or more. After this treatment, the seeds are removed and dried, or blotted with newspaper, and are then mixed with dry sand so that they may be handled readily; they should be planted immediately. They are not washed with water after the immersion in the copper solution.

The second treatment is with monohydrated-copper-sulfate dust. This is the same material that is used to make the copper-lime dust. A quart fruit jar is filled about half full of tomato seeds, and a tablespoonful of the dust is sprinkled over them. The jar is then closed tightly and shaken until every seed has a coating of the dust. The treated seeds are planted in the usual manner.

Copper carbonate may be used as the dust in place of the monohydrated copper sulfate. The treatment in both cases is the same. A similar treatment of spinach seed has proved equally effective in the control of damping-off of that crop.

INSECTICIDES AND FUNGICIDES

BORDEAUX MIXTURE

Almost the only spray used on vegetables is bordeaux mixture. This is made by mixing a solution of copper sulfate (blue vitriol) with milk of lime. A mixture made from 4 pounds of copper sulfate and 4 pounds of lime to 50 gallons of water is indicated by the formula 4–4–50; 5 pounds of copper sulfate and 5 pounds of lime to 50 gallons of water, by 5–5–50, and so on. In order to make bordeaux mixture of any strength, the procedure should be as follows:

A stock solution of copper sulfate is made in a barrel from 50 pounds of copper sulfate dissolved in 50 gallons of water. If the crystals, placed in a gunny sack, are suspended just beneath the surface of the water, they will dissolve in the course of three or four hours.

A stock mixture of lime is made by mixing 50 pounds of chemical hydrated lime in 50 gallons of water. Some investigators prefer 50 pounds of freshly slaked burned lime in place of the hydrated material. Air-slaked lime, or hydrated lime that contains much magnesium, should not be used.

The sprayer is filled three-fourths full of water. If a 4–4–50 solution is desired, 4 gallons of copper sulfate stock solution is added to this water for every 50 gallons of mixture to be made. The solution requires stirring until it is well diluted, after which 4 gallons of the stock mixture of milk of lime is added to each 50 gallons of the mixture. The lime water is run through a strainer in order to prevent the larger par-

ticles of lime from getting into the spray tank. While the milk of lime is being added to the dilute copper-sulfate solution in the sprayer tank, the material in the tank should be stirred constantly. The sky-blue bordeaux mixture will result. Enough water to make the required amount of mixture must now be added. The milk of lime may be added first if desired. Calcium arsenate or lead arsenate may be added to the bordeaux mixture if insects are to be controlled. For making small quantities of the fungicide, 4 ounces of copper sulfate, 4 ounces of hydrated lime, and 3 gallons of water are necessary.

If only a small amount of the spray material is required, prepared bordeaux mixtures are available on the market and prove handy. But in larger quantities they are expensive as compared with the home-mixed material.

COPPER-LIME DUST

Some growers prefer the use of dust instead of the liquid application. The dust is made of copper sulfate (blue vitriol), the best grade of chemical hydrated lime, and sometimes calcium arsenate. The copper sulfate is dried thoroughly and ground exceedingly fine. This is then put on the market as monohydrated copper sulfate. It may be bought already mixed with the lime or obtained separately and mixed at home. The formula for the dust is 20 pounds of the copper sulfate and 80 pounds of the lime. If 20 pounds of calcium arsenate is added, the formula is written 20–20–60.

The dusting can be done only when the plants are wet with dew or rain. If the dust is put on when the foliage is dry, the copper is washed off by the next shower and will be of no value. For this reason the dusting is done late in the evening or just after daybreak. All parts of the plant should be covered thoroughly. It is not enough merely to walk along one side of a vegetable row and apply the dust with a hand machine. It is necessary to move the nozzles from one side to the other and at different angles, so that every leaf is treated uniformly. If a horse-drawn duster is used, there should be three nozzles for each row of plants except when the plants are very small. One of the nozzles should be directed straight downward and one on each side of the row directed inward at the same angle that the branches or the leaves of the plant extend from the main stem.

NICOTINE

For spraying purposes, nicotine is usually sold in the form of nicotine sulfate. The standard brands of nicotine sulfate on the market contain 40 per cent of nicotine. The recommendations in this bulletin are based on a product of that strength. Nicotine sulfate is not volatile, but the fumes of the nicotine are liberated when the material is applied as a

spray in combination with soap. Nicotine sulfate is not effective when mixed with water only. It is not so effective in combination with bordeaux mixture as when used with soap.

For greenhouse use, nicotine is often sold in the form of a 40 per cent solution, the nicotine being in the "free," or uncombined, form.

Nicotine dust is usually made by mixing nicotine sulfate with hydrated lime. Nicotine-lime dusts can be bought ready-mixed, or they may be prepared at home in a ball mixer or in a self-mixing duster. Since the commercial brands of nicotine sulfate contain 40 per cent, by weight, of nicotine, 5 pounds, or 2 quarts, of this material is added to 95 pounds of hydrated lime to give a dust containing 2 per cent of nicotine. For a 3-per-cent-nicotine–lime dust, 7½ pounds, or 3 quarts, is required, for a 4 per cent mixture, 10 pounds, or 1 gallon. To produce an effective dust, it is necessary to mix the materials so thoroughly that each particle of lime carries a bit of nicotine. This can be easily accomplished by using a self-mixing duster or a ball mixer. Unless the grower is going to use enough of the dust to make it worthwhile to purchase or construct a good mixer, it will be more profitable to buy the dust ready-mixed.

A servicable mixer can be built for home-mixing at a reasonable cost. A 50-gallon cider barrel is used for mixing the dust. An opening 6 by 8 inches is cut out in the side for a door, which is attached with strap hinges and fastened with a button. The edges should be padded to prevent leakage. In the center of each end of the barrel fasten a 1¼- by 1-inch bushing. In each bushing screw a piece of 1-inch pipe 6 inches in length. These will serve as an axle on which to rotate the barrel. The barrel is then mounted, at a convenient height, so that it can be rotated by a crank attached to one end of the axle.

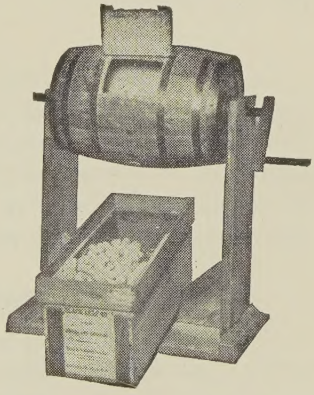

FIGURE 11. MACHINE FOR HOME-MIXING NICOTINE-LIME DUST

To make the dust, put 50 pounds of hydrated lime in the barrel. Then pour the proper amount of nicotine sulfate on top of the lime. For each pound of the dust add about ½ pound of hard stones or pebbles, from ¾ inch to 1½ inches in diameter, to aid in the mixing. The barrel should then be rotated rather slowly, thirty-five revolutions per minute, for not less than five minutes. It is better to use a watch and not to guess at the time. When the mixture is finished, the dust should be dumped out into a box provided with a screened lid to remove the stones. The dust should be stored in tight metal drums or, if to be used at once, placed in paper sacks such as are used for lime.

The quantity of nicotine sulfate to use with 50 pounds of hydrate lime is indicated in the following table:

Strength of dust desired	Quantity of nicotine sulfate to use for 50 pounds of lime
1 per cent	1¼ pounds, or 1 pint
2 per cent	2½ pounds, or 2 pints
3 per cent	3¾ pounds, or 3 pints
4 per cent	5 pounds, or 4 pints

Since the nicotine strength is likely to deteriorate if the dust is stored for a considerable time, a fresh product is desirable.

SOAP

Soaps are used with nicotine sulfate and water to liberate the nicotine and to increase the wetting and spreading qualities of the spray. The most satisfactory soap for this purpose is potash fish-oil soap. This is a soft soap, dissolving easily in water. The harder soda fish-oil soaps and laundry soap are unsatisfactory because of the difficulty of dissolving them. Soaps vary greatly in water content. The amount to use, therefore, varies considerably, usually from 3 to 5 pounds in 100 gallons of the spray mixture.

PYRETHRUM

Several brands of pyrethrum products in which the active ingredients, pyrethrins, are combined in various ways with alcohols or soaps are on the market. These preparations are usually too expensive for use on a large scale in commercial plantings. Because these preparations are more poisonous than nicotine at economical dilutions against certain insects, particularly beetles, they have a certain field of usefulness.

MAGNESIUM ARSENATE

The commercial use of magnesium arsenate is restricted almost entirely to the control of the Mexican bean beetle. It is preferred for this purpose because it is less likely to injure bean foliage than is lead or calcium arsenate.

LEAD ARSENATE

Lead arsenate, so widely used for orchard spraying, is now little used on vegetable crops, being largely replaced for this purpose by calcium arsenate. It was formerly sold in the paste form, but is now manufactured as a dry powder. The directions in this bulletin for the quantity to use are based on the dry form. If the paste is used, twice as much as that recommended for the dry form is required.

CALCIUM ARSENATE

Calcium arsenate has now largely replaced lead arsenate for use on most vegetable crops. It is safe to use on the foliage, is cheaper than lead arsenate, and acts more quickly as an insect poison. It is manufactured in the form of a white, light, fluffy powder.

FLUOSILICATES

A number of commercial preparations of barium, calcium, and sodium fluosilicates are on the market. They are sold under various trade names. For use on beans, the barium and calcium fluosilicates have been found less likely to injure the foliage than has the sodium.

Go Together

YOU, reader of this bulletin, are likely to be interested in growing vegetables; if you are, you can't help being engaged in a warfare against insects, because insects and plants go together, generally to your sorrow.

Sometimes, however, insects are decidedly a benefit, as honeybees, which not only supply a healthful, palatable food, but also help the set of fruit in apple orchards.

Cornell has free bulletins for you on both insects and vegetables. If you need any of the following, why not ask for them? They are free.

The family garden (E 74) *R. M. Adams*

Commercial varieties of vegetables for New York State (E 176) *Schneck*

Home storage of vegetables (E 196) *R. M. Adams*

Address your request, on a postcard, to

Office of Publication
College of Agriculture
Ithaca, New York

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